A STUDY ON VARIATION OF TEST CONDITIONS ON CBR DETERMINATION

A thesis submitted in the partial fulfilment of the requirements for the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

BY

SUBHASH TOMAR (107CE001)

TAPAS KUMAR MALLICK (107CE016)

UNDER THE GUIDANCE OF

PROF.M.PANDA

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

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CERTIFICATE

This is to certify that the thesis entitled, "**A STUDY ON VARIATIONS OF TEST CONDITIONS ON CBR DETERMINATION**" submitted by **MR. SUBHASH TOMAR (ROLL-107CE001)** AND **MR. TAPAS KUMAR MALLICK (ROLL-107CE016)** in partial fulfilment for the award of the Degree of Bachelor of Technology in Civil Engineering, National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matters enclosed in the thesis have not been submitted to any other university/Institute for the award of any Degree or Diploma.

PROF.M.PANDA
PROF. CIVIL ENGG.
NIT ROURKELA

ACKNOWLEDGEMENTS

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SUBHASH TOMAR

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B.TECH.,8th SEM ,

CIVIL ENGG. DEPT.

CONTENTS

LISTS OF TABLES

LIST OF FIGURES

ABSTRACT

The California Bearing Ratio Test (CBR Test) is a test first developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of sub grade soil for design of flexible pavement. The CBR value of the sub grade soil is being used widely since a long time in design of pavement structure and is critical in deciding the overall thickness of the pavement. Additionally, for good drainage, a typical specification for the pavement foundation design requires the value of permeability coefficient of the sub grade material to be specified. Thus, permeability and CBR constitute two important parameters in the design and assessment of long-term performance of the pavement. In this project only strength aspects of pavement subgrade have been considered. In this study, laboratory investigations have been carried out on a number of soil samples procured from different roadwork sites. Preliminary tests, such as index tests and particle size distribution tests, used for soil classification, have been taken up followed by Proctor compaction and CBR tests. CBR tests have been conducted for same samples under various conditions of soaking, with due emphasis on moisture content parameters in the soil sample. In this study for the purpose of comparison two different types of soils have been considered to study the variations

1. *INTRODUCTION*

1.1 General

A pavement is a durable surface having materials laid down on an area subjected to sustain mainly the vehicular traffic, such as a road or highway. A pavement is typically a structure of various layers resting over soil either in embankment or in cutting. In the past, cobblestones and granite sets were extensively used, but these surfaces have mostly been replaced by asphalt or concrete now-a-days. A pavement is classified in general in two categories, i.e. namely a flexible pavement and a rigid pavement. The flexible pavement consists of granular layers of superior quality in upper layers with a preferably bituminous topping, while a concrete pavement consists of a cement concrete slab over occasional granular layers. The design of pavement has seen several modifications over the years. Traditionally the design of either kind of pavement is based on the strength of the compacted soil in the pavement, called subgrade. The design of the pavement layers laid over the subgrade soil starts off with the determination of subgrade strength and the traffic volume which is to be carried. The design of pavement is very much dependent on the subgrade strength of soil. Design criteria mainly needs thickness of layers. Weaker subgrade needs thicker layers whereas stronger subgrade needs thinner pavement layers. The Indian Road Congress (IRC) provides the exact procedures for the pavement layers design which based upon the subgrade strength. The strength of a subgrade soil is normally expressed in terms of the California Bearing Ratio (CBR).

Due to variable nature of soil, the subgrade strength changes inconsistently, as a result engineers face so many difficulties or challenges during the design of a pavement. The subgrade strength is very much dependent on moisture content. As the subgrade is intended to variation of moisture due to flood, precipitations or all other climatic changes, so it is necessary to enable or understand the subgrade according to the variation of moisture..

The CBR is the only test which can figure out the strength of a subgrade. By this test we can compare the strength of different subgrade materials .The CBR test is done in a standard manner by which one can find out or design the strength or thickness of subgrade layer. CBR value is inversely proportional to thickness of the pavement layer. If the subgrade is stronger, the higher is the CBR value, so lesser thickness is required and vice-versa.

1.2 Objectives

This project attempts to understand and investigate the variations of CBR with moisture contents resulting due to different periods (days) of soaking and to assess the influence of test conditions in determination of CBR value. Thus, various soil samples with different densities and moisture content are to be calculated in terms of CBR test for determination of their strengths at variable water contents by soaking the soil samples in water bath for variable number of days. A detailed analysis of results has to be carried out to get this inference.

1.3 Scope of work

- To collect various soil samples from different sites of work and to find its basic physical properties such as plastic limit, liquid limit, and grain size distribution.
- To study the soil under heavy compaction test and determine the optimum moisture content (OMC) and maximum dry density (MDD) for the soil sample.
- To conduct CBR test on different soil samples under different moisture contents over varying days of soaking.
- To study the submergence of soil under different days of soaking.

2. *REVIEW OF LITERATURE*

2.1 Subgrade soil

2.1.1. Significance of subgrade soil

Subgrade soil is the integral part of the road pavement structure which provides support to the pavement. The subgrade and its different properties are very much important in the pavement design structure. The major function of the subgrade is to provide the support to the pavement against traffic loading and for this the subgrade should possess sufficient stability under adverse climate and heavy loading conditions.

When soil is used in the embankment construction, along with stability incompressibility is also an important factor as differential settlement may cause failures. Compacted and stabilized soil is often used as sub-base or base course. The soil or subgrade is therefore considered as one of principal highway material.

2.1.2. Subgrade strength

The strength of a soil or subgrade can be determined by using a test known as California Bearing Ratio Test which was developed in California in the year 1930's and it is way to determine the standard soil properties such as density. It is graph showing the values for aspect of design of road pavement.. Mostly all the design charts are based on the value of CBR for the subgrade.

2.1.3. Subgrade performance

A subgrade characteristics mainly depends on the following three factors such as

2.1.3.1. Load bearing capacity. The subgrade resists loads which are transmitted from the pavement structure. Various factors such as degree of compaction, moisture content, and nature of soil affect the load bearing capacity of soil. A subgrade without excessive deformation sustain heavy loading is considered good.

2.1.3.2. Moisture content. Properties such as load bearing capacity, shrinkage and swelling etc. are mostly affected by the variation of moisture content. Various things such as drainage, groundwater table elevation, infiltration, or pavement porosity etc. Influence the moisture content. Highly wet subgrades deform more under loading..

2.1.3.3. Shrinkage and/or swelling. Shrinkage or swelling mainly depends on moisture content. Additionally, in frost conditions (in northern climate) soils with excessive fine content may be susceptible to frost heave. Shrinkage, swelling and frost heave are the factors whose tendency is to deform and crack any pavement structure construed over them.

2.2 Desirable properties

The desirable properties of sub grade soil as a highway material are

- Withstand capability (Stability)
- Ease of compaction.
- Strength permanency
- Low change in volume during adverse conditions of weather and ground water table.
- Superior drainage
- Incompressibility

2.3. Soil types-(reff.5)

For the design of any highway construction pavement, it is obligatory for the civil engineers to identify and classify the soil as per the nature.. Broadly, the soil types can be categorized as Laterite soil, Moorum / red soil, Desert sands, Alluvial soil, Clay including Black cotton soil.

- **Gravel:** Gravels are course materials with particle size less than 2.36 mm with little or no fines contributing to cohesion of materials.
- **Moorum:** These are the decomposition and weathering products of the pavement rock. These are the finer contents and visually similar to that of gravel.
- **Silts:** Silts are finer than sand and exhibit little cohesion .as compared to clay, these are brighter in colour. Another property of this soil is dilatancy, i.e. a lump of silty soil when mixed with water, it squeezed and tapped a shiny surface makes its appearance.
- **Clays:** These are finer materials. These kinds of soils possess stickiness, high strength when dry, and show no dilatancy. Soils like Black cotton and other expansive clays show swelling and shrinkage properties.

Table-1 soil classification based on grain size(reff.4)

Gravel	Sand			Silt			Clay		
	coarse	medium	fine	coarse	medium	fine	coarse	medium	fine
	0.6mm	0.2mm		0.02mm	0.006mm		0.0006mm	0.0002mm	
2.0mm			0.06mm			0.002mm			

2.4 Index properties of soil

2.4.1 Liquid limit test-

The liquid limit is the moisture content corresponding to the boundary between liquid and plastic states of soil mass. At liquid limit the soil has such a low shear strength (17.6g/cc) which flows to standard dimension for a length of 12mm of a groove when jarred 25 times using the standard liquid limit device. Casagrande apparatus is one of the apparatus used for determining the liquid limit. The water content at which 25 drops of the cup to make the groove to close is called as the liquid limit.

2.4.2 Plastic limit test-

The plastic limit (PL) is the moisture content at which the soil remains in plastic state. It is the water content at which the soil just begins to crumble when rolled into a thread of 3mm diameter.

2.4.3 Plasticity index-

Plasticity Index ($\mathbf{I_P}$)=Liquid Limit($\mathbf{W_L}$) -Plastic Limit ($\mathbf{W_P}$)

2.5 California Bearing Ratio (CBR)

The CBR test was first introduced or developed by O.J. Porter at California Highway Department in 1920. It is otherwise called as load-deformation test which is conducted in the laboratory or in the fields and these results are generally used to find the thickness of pavement layers, base course and other layers of a given traffic loading by the use of empirical design chart. First it was adopted by the US Army Corps of Engineers (USACE) for the design of flexible airfield pavements. Initially it practiced for the design of surfaced and un-surfaced airfields which is still based upon CBR today. The CBR determination is performed in the laboratory mainly on recompacted soil or in the field and the field CBR is normally used by the military for contingency roads and design of airfields.

The CBR determines the thickness of different elements constituting the pavement. The CBR test is the ratio of force per unit area required to penetrate soil mass by a circular plunger of 50mmat the rate of 1.25mm/min. Observations are carried out between the load resistances (penetration) vs. plunger penetration.. The California bearing ratio, CBR is expressed as the ratio of the load resistance (test load) of a given soil sample to the standard load at 2.5mm or 5mm penetration, expressed in percentage .

$$CBR = (\text{Test load}/\text{Standard load})\times 100$$

The standard load for 2.5mm and 5mm penetrations are 1370 kg and 2055 kg respectively. The CBR test is carried out on a small scale penetration of dial reading with probing ring divisions. The probing ring divisions are taken corresponding to the penetrations at 0,0.5,1,1.5,2,2.5,3,3.5,4,4.5,5,5.5,6,6.5,7,7.5,8,8.5,9,9.5,10,10.5,11,11.5,12,12.5 and from which test loads are calculated and hence CBR value of soil is being determined.

3. ***EXPERIMENTAL INVESTIGATIONS***

3.1 Investigation-

The entire investigations have been conducted on two type of soil, .i.e. 1.Red Moorum Soil (from NIT Rourkela campus) & 2.Black Cotton Soil (from Bonai, Sundergarh District). Initially experiments were conducted to find out different properties of soil such as index properties, grain size distribution etc. Later on heavy compaction tests were conducted to find out the optimum moisture content & corresponding maximum dry density. Then CBR tests were made at different moisture contents including OMC and analysis made to investigate the variation of CBR with respect to different days of soaking, i.e. from unsoaked (day 0) to soaked (day 5). The variations were also made with regard to moisture content at different layers along with different positions (east, west, north, south, centre positions) and also the variations of moisture content with respect to different days of soaking were observed.

3.2 Grain size distribution

3.2.1 Dry sieve analysis

About 1kg of soil was taken and it was washed thoroughly with water on 75 micron sieve ,soil retained on sieve was dried and weighed and used for sieve analysis .These dried soils were passed through stack of sieves like 4.75mm,2.36mm,1.18mm,600µm,300 µm,150 µm 0,75 µm. The soils that retained on these sieves were used for the grain size distribution curve.

3.2.2 Hydrometer analysis

About 50 gm of soil was taken and 2% solution of sodium hexameta phosphate was added to it and distilled water was added .Then the soaked soil was transferred to dispersion cup and was stirred for 15 minutes. Then the soil mixture was poured into the standard measuring flask and made total volume of soil suspension exactly by 1000cc.Finally the hydrometer was calibrated and different corrections was made from tables, charts provide to us.

3.3 Liquid limit test

A sample of 200gm of soil and appropriate water was thoroughly mixed to form a paste. The soil paste was then placed in the cup of the liquid limit device and a grove was made in middle of soil along the diameter, dividing the soil into 2 parts .then handle of the device was turned till the 2 parts in the cup joined Then no of blows was noted and small quantity of soil was taken for determination of moisture content.

3.4 Plastic limit test

Around 300 gm of soil was taken and mixed with sufficient amount of water and then a portion of soil was taken into a ball and rolled it into a thread of uniform diameter. Then some crumbled soil pieces were taken for calculation of moisture content.

3.5 Compaction test

2500g of oven dry soil was passed through the 4.75mm sieve. Enough water was added to the sample 7% (sandy soil) &10% (clayey soil). The soil was compacted into the mould in FIVE layers using a 10 pound hammer and 25 blows per layer. Weighed the mould and the sample and recorded on data sheet. Small quantity of soil sample was taken for determining moisture content. The experiment was repeated by increasing the moisture content by 4%. A graph was plotted between water content vs. dry density to scale on graph paper and optimum moisture and maximum dry unit weight was indicated.

3.6 CBR Test

Using the moisture content and corresponding dry density the amount of soil used for CBR was calculated. The sample was tested using the CBR instruments and each soil sample was soaked for 1 day, 2 day, 3 day, 4 day, 5 day and corresponding CBR values was found out. Unsoaked CBR was also determined for every sample. Also the moisture content at different points (i.e., at different height &at its different locations like north, south, east, west and centre) was determined.

4. *ANALYSIS OF RESULTS AND DISCUSSIONS*

4.1 Soil Sample 1

4.1.2 Index Properties-

The results of index properties of soil sample 1 are as follows

Table 2-index properties of soil

Index property	Experimental value (%)
Liquid limit	37.6
Plastic limit	23.4
Plasticity index	14.2

4.1.2 Grain size distribution-

Table 3- The grain size distribution of this soil

I.S. sieve	weight retained in (gm)	percentage weight retained	Cumulative percentage retained	percentage weight passing(%)
4.75 mm	19.9	1.99	1.99	98.01
2.36 mm	16.6	1.66	3.65	96.35
1.18 mm	37.3	3.73	7.38	92.62
0.6mm	41	4.1	11.48	88.52
0.3 mm	93.1	9.31	20.79	79.21
0.15mm	123.6	12.36	33.15	66.85
0.075mm	56.2	5.62	38.77	61.23

Result

As 50% soil passing, the soil was a fine graded soil and as liquid limit <50%, so the soil is clay (CL)

Table 4. Hydrometer analysis

Elapsed Time t (min)	Hydrometer Reading Rh'	Temp °C	Correc-tion C	Rh=Rh'+Cm	Effective Depth He (cm)	Factore F	Particle size D (mm)	R= Rh' +C	%finer (N') based on Md	%finer(N) based on whole N=N'xM'/M
0.5	19	29	0	19.5	12.69	1205	0.060706	19.5	61.674	55.81535
1	17.5	29	0	18	13.26	1205	0.043879	18	56.930	51.52186
2	16.5	29	0	17	13.64	1205	0.031469	17	53.767	48.65953
4	15	29	0	15.5	14.21	1205	0.022712	15.5	49.023	44.36605
5	14.5	29	0	15	14.4	1205	0.02045	15	47.441	42.93488
6	14	29	0	14.5	14.59	1205	0.018791	14.5	45.860	41.50372
9.5	13	29	0	13.5	14.97	1205	0.015126	13.5	42.697	38.6414
11	12.5	29	0	13	15.16	1205	0.014146	13	41.116	37.21023
13	12	29	0	12.5	15.35	1205	0.013094	12.5	39.534	35.77907
15	11.5	29	0	12	15.54	1205	0.012265	12	37.953	34.34791
20	11	29	0	11.5	15.73	1205	0.010687	11.5	36.372	32.91674
25	10.5	29	0	11	15.92	1205	0.009616	11	34.790	31.48558
30	10	29	0	10.5	16.11	1205	0.00883	10.5	33.209	30.05442
35	9	29	0	9.5	16.49	1205	0.008271	9.5	30.046	27.19209
45	8.5	29	0	9	16.68	1205	0.007336	9	28.465	25.76093
60	8	29	0	8.5	16.87	1205	0.00639	8.5	26.883	24.32977
280	5	29	0	5.5	18.01	1205	0.003056	5.5	17.395	15.74279
1402	2.5	29	0	3	18.96	1205	0.001401	3	9.4883	8.586977

Grain size distribution curve

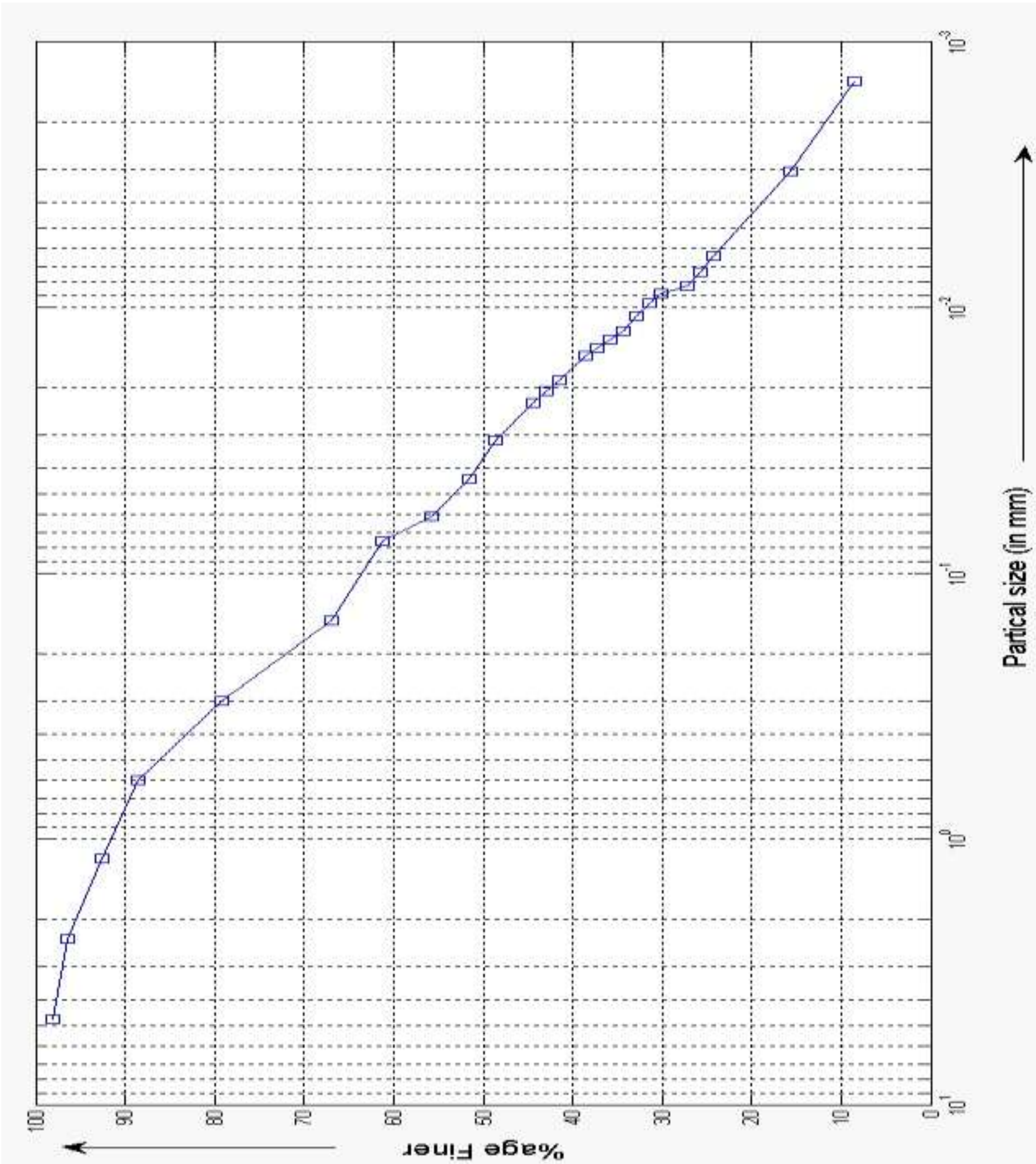


Fig-1

4.1.3 Modified Proctor test-

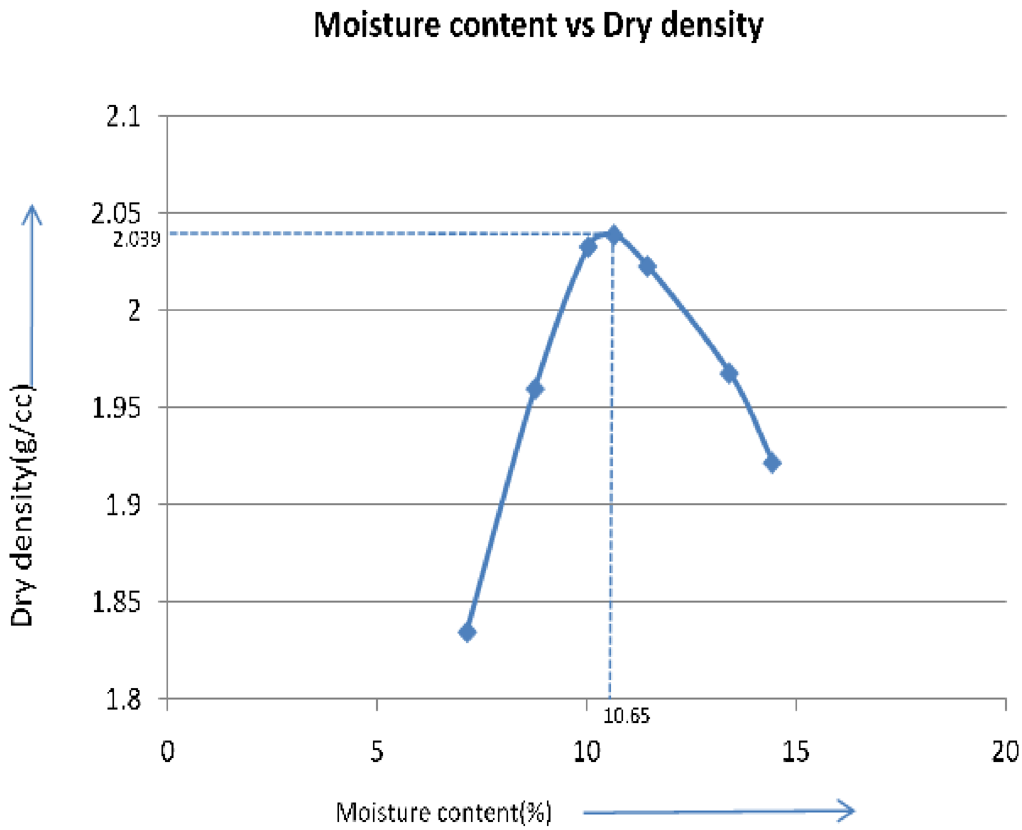


Fig-2

From the graph plotted between Moisture content vs. Dry density, it was found that

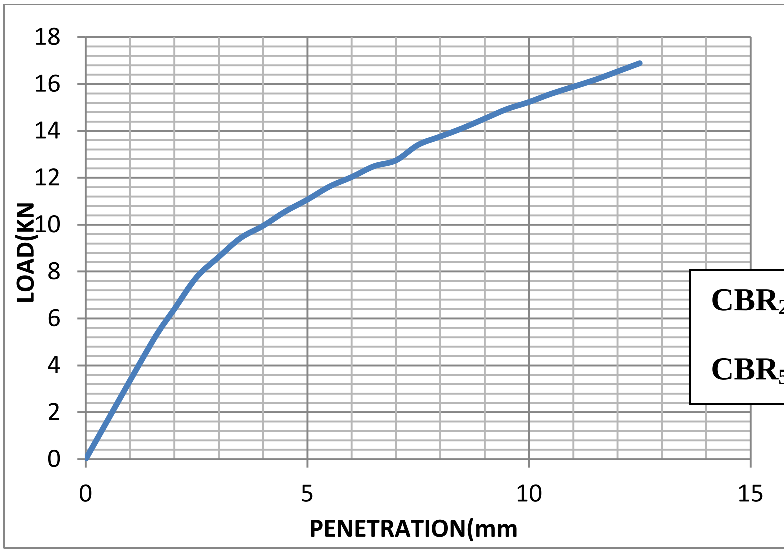
MDD = 2.039 g/cc

OMC = 10.65 %

4.1.4 CBR Tests-

4.1.4.1 Test-1(conducted under omc (10.65%) and mdd (2.039 g/cc)

Un-soaked (Day 0)

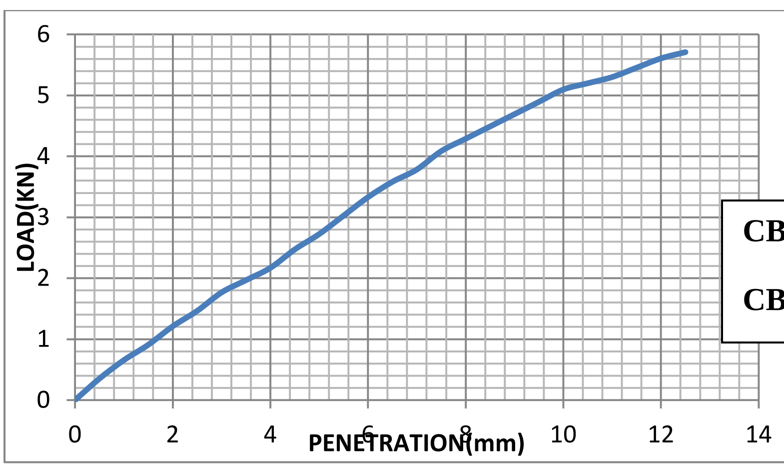


$CBR_{2.5mm}$=(622/1370)*100=48.03

CBR_{5mm}=(923.4/2055)*100=45.56

Fig-3

Soaked (DAY 1)-

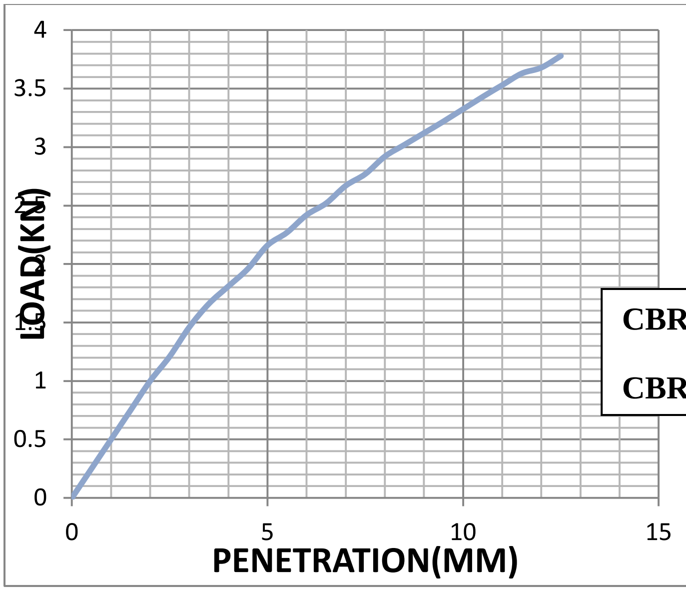


$CBR_{2.5mm}$=(146.31/1370)*100=10.7

CBR_{5mm}=(272.45/2055)*100=13.25

Fig-4

Soaked (DAY 2)-

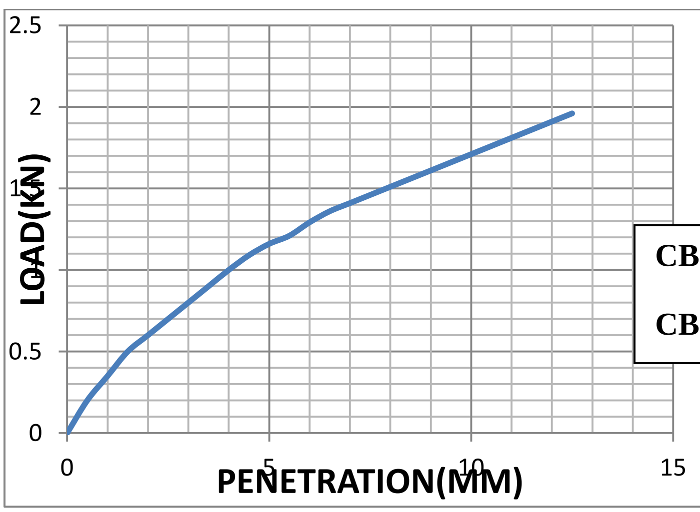


$CBR_{2.5mm}$=(121.09/1370)*100=8.8

CBR_{5mm}=(216.95/2055)*100=10.5

Fig-5

Soaked(DAY 3)-

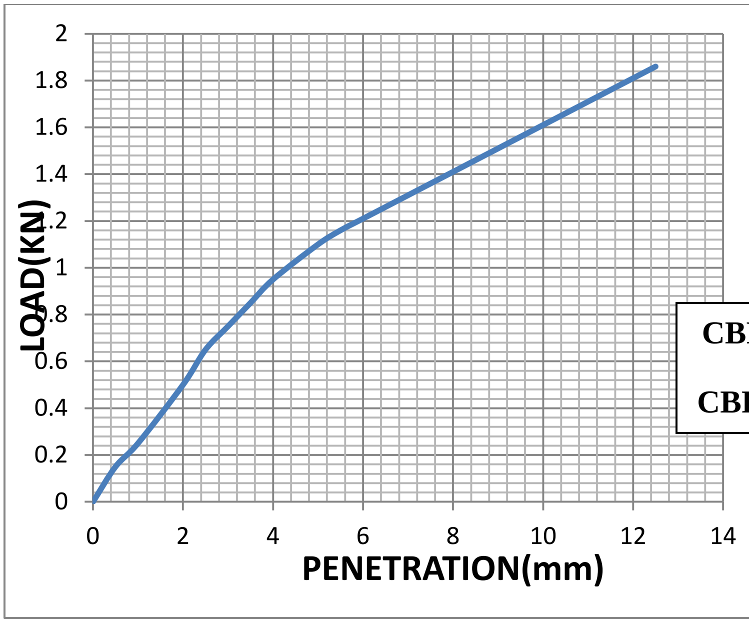


$CBR_{2.5mm}$=(70.63/1370)*100=5.2

CBR_{5mm}=(116.04/2055)*100=5.6

Fig-6

Soaked (DAY 4)-

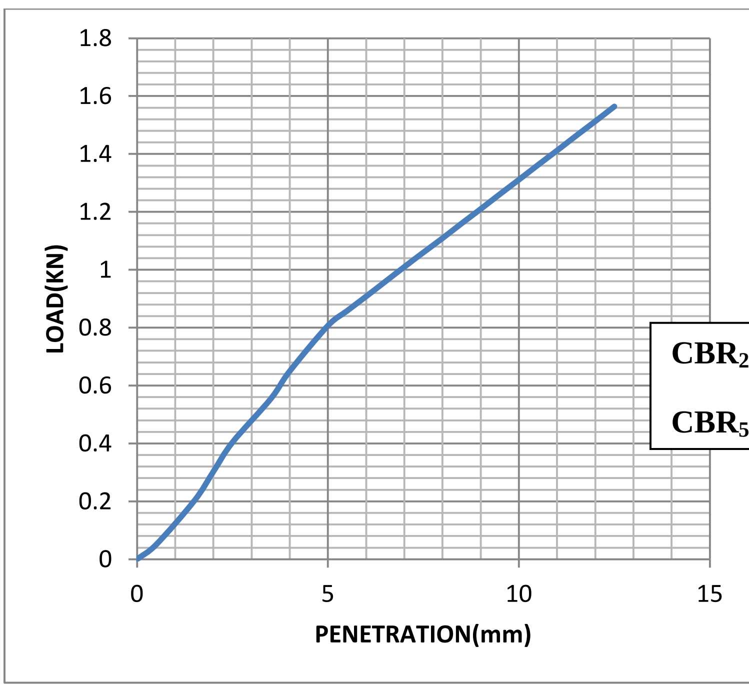


$CBR_{2.5mm}$=(65.59/1370)*100=4.8

CBR_{5mm}=(110.998/2055)*100=5.4

Fig-7

Soaked (DAY 5)-



$CBR_{2.5mm}$=(40.4/1370)*100=2.95

CBR_{5mm}=(80.7/2055)*100=3.9

Fig-8

Table- 5

Moisture content in %							
Unsoaked		Centre	East	West	North	South	Avg.
	Top	11.92	12.46	12.48	12.37	12.42	12.33
	Middle	12.43	12.30	12.06	12.16	12.54	12.30
	Bottom	12.76	12.52	12.83	12.87	13.28	12.85
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	15.16	16.05	16.41	14.80	16.75	15.83
	Middle	14.03	13.74	13.41	13.85	13.57	13.72
	Bottom	13.28	13.55	13.56	13.41	13.49	13.46
Soaked Day-2		Centre	East	West	North	South	Avg.
	Top	16.42	15.88	16.21	15.25	15.59	15.87
	Middle	14.58	14.35	14.09	14.11	14.26	14.28
	Bottom	13.66	13.31	13.78	13.70	13.04	13.50
Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	15.83	16.80	17.05	16.47	16.70	16.57
	Middle	14.29	14.10	13.75	14.47	14.39	14.20
	Bottom	13.38	13.37	13.54	13.50	13.22	13.40

		Centre	East	West	North	South	Avg.
Soaked Day-4	Top	16.29	17.42	17.39	18.01	16.58	17.14
	Middle	14.18	14.23	13.65	14.01	13.76	13.97
	Bottom	13.87	13.67	13.80	13.90	13.97	13.84
Soaked Day-5		Centre	East	West	North	South	Avg.
	Top	18.77	23.18	20.11	21.58	23.41	21.41
	Middle	15.62	15.14	15.27	14.68	15.69	15.28
	Bottom	14.47	14.88	15.25	15.10	15.51	15.04

VARIATION OF MOISTURE WITH RESPECT TO DAYS OF SOAKING-

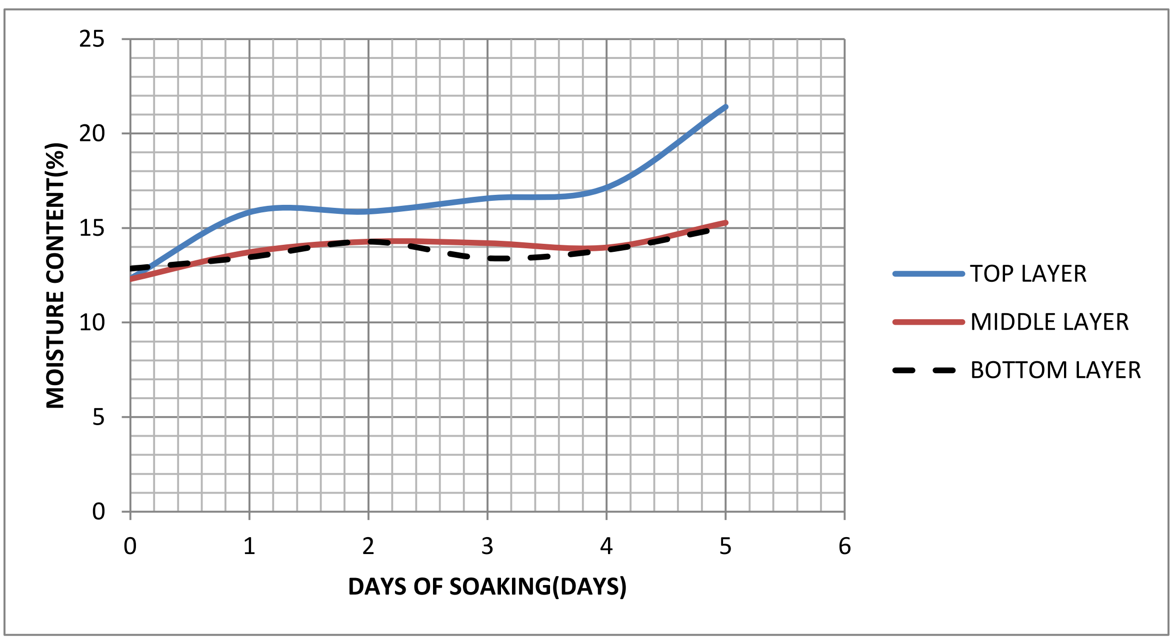
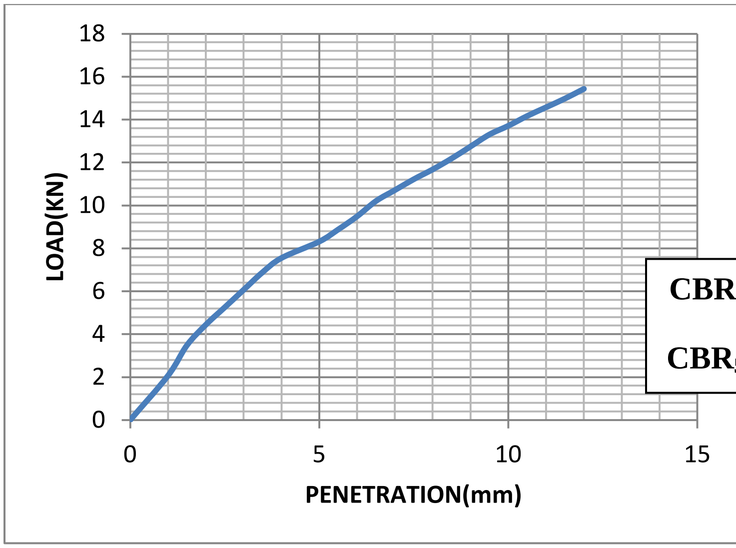


Fig 9

4.1.4.2 Test-2-Using moisture content= 9% Corresponding drdensity=1.98 g/cc

Unsoaked (DAY 0)

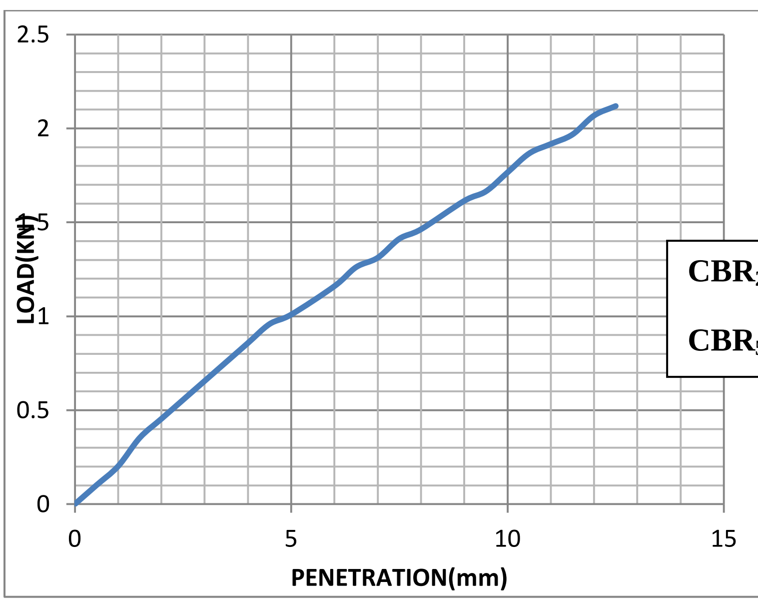


$CBR_{2.5mm}$=(559.05/1370)*100=40.81

CBR_{5mm}=(843.46/2055)*100=41.04

Fig-10

SOAKED (DAY 1)

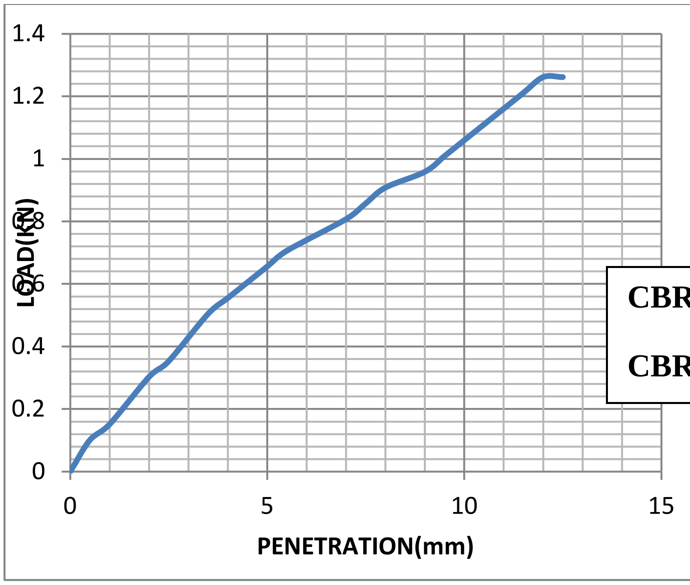


$CBR_{2.5mm}$=(55.4995/1370)*100=4.05

CBR_{5mm}=(100.9082/2055)*100=4.91

Fig-11

SOAKED (DAY2)

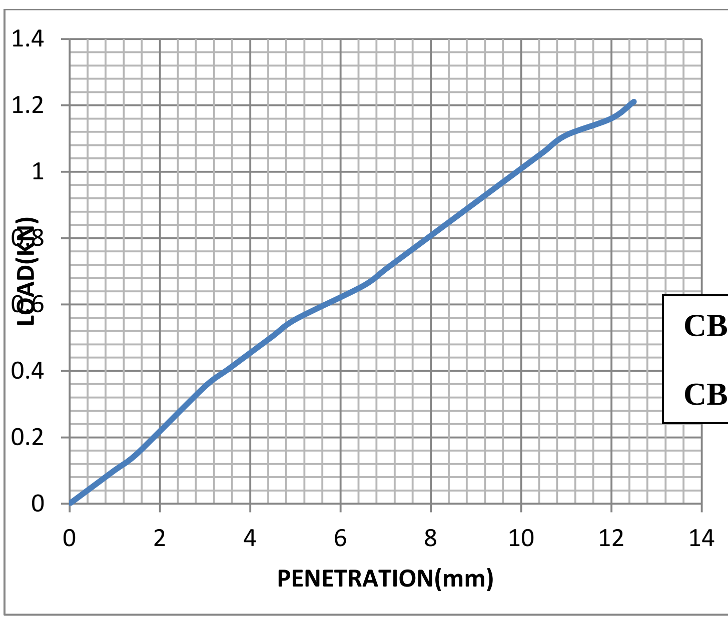


$CBR_{2.5mm}$=(35.31786/1370)*100=2.57

CBR_{5mm}=(65.59031/2055)*100=3.19

Fig-12

SOAKED (DAY3)

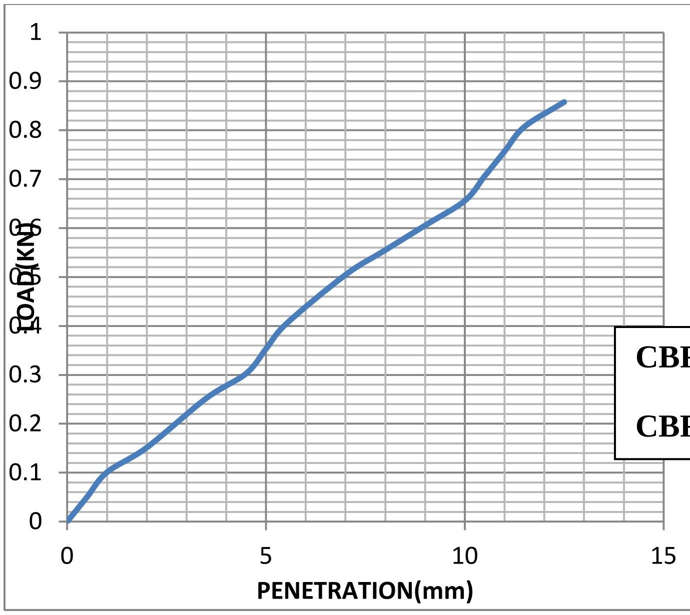


$CBR_{2.5mm}$=(25.22704/1370)*100=1.84

CBR_{5mm}=(55.4995/2055)*100=2.7

Fig-13

SOAKED (DAY4)

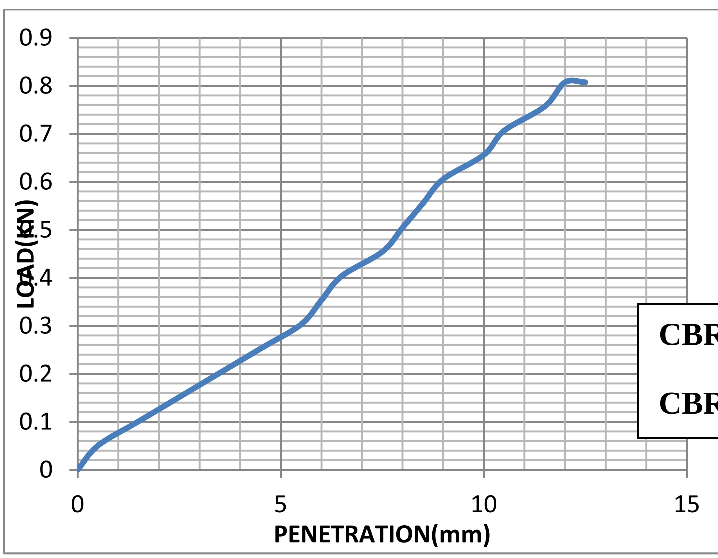


$CBR_{2.5mm}$=(15.13623/1370)*100=1.11

CBR_{5mm}=(35.31786/2055)*100=1.72

Fig-14

SOAKED (DAY5)



$CBR_{2.5mm}$=(15.13623/1370)*100=1.1

CBR_{5mm}=(30.27245/2055)*100=1.47

Fig-15

Table- 6

Moisture content in %							
Unsoaked		Centre	East	West	North	South	Avg.
	Top	10.33	9.84	11.69	10.63	10.76	10.65
	Middle	10.41	10.53	9.95	10.96	10.46	10.46
	Bottom	12.64	10.66	10.16	10.63	11.17	11.05
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	16.04	16.48	15.24	16.57	16.31	16.13
	Middle	12.33	12.78	12.54	13.47	13.02	12.83
	Bottom	13	14.57	13.84	14.57	14.12	14.02
Soaked Day-2		Centre	East	West	North	South	Avg.
	Top	16.75	16.27	16	16.31	16.16	16.29
	Middle	15.27	15.19	14.35	15.35	14.73	14.98
	Bottom	14.41	14.92	14.56	15.04	14.71	14.73

Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	16.26	16.83	16.83	16.88	16.91	16.74
	Middle	14.83	14.59	14.4	14.51	14.32	14.53
	Bottom	14.13	14.26	14.27	14.21	14.11	14.2

		Centre	East	West	North	South	Avg.
Soaked Day-4							
	Top	16.89	16.59	16.95	17.23	16.72	16.87
	Middle	15.13	14.78	14.56	15.42	14.99	14.98
	Bottom	13.86	14.43	14.16	14.45	13.99	14.18
Soaked Day-5		Centre	East	West	North	South	Avg.
	Top	17.15	18.46	17.53	18.05	17.23	17.68
	Middle	16.20	15.15	15.32	15.47	16.19	15.66
	Bottom	15.25	15.33	15.5	15.36	15.3	15.34

Variation of moisture with respect to days of soaking

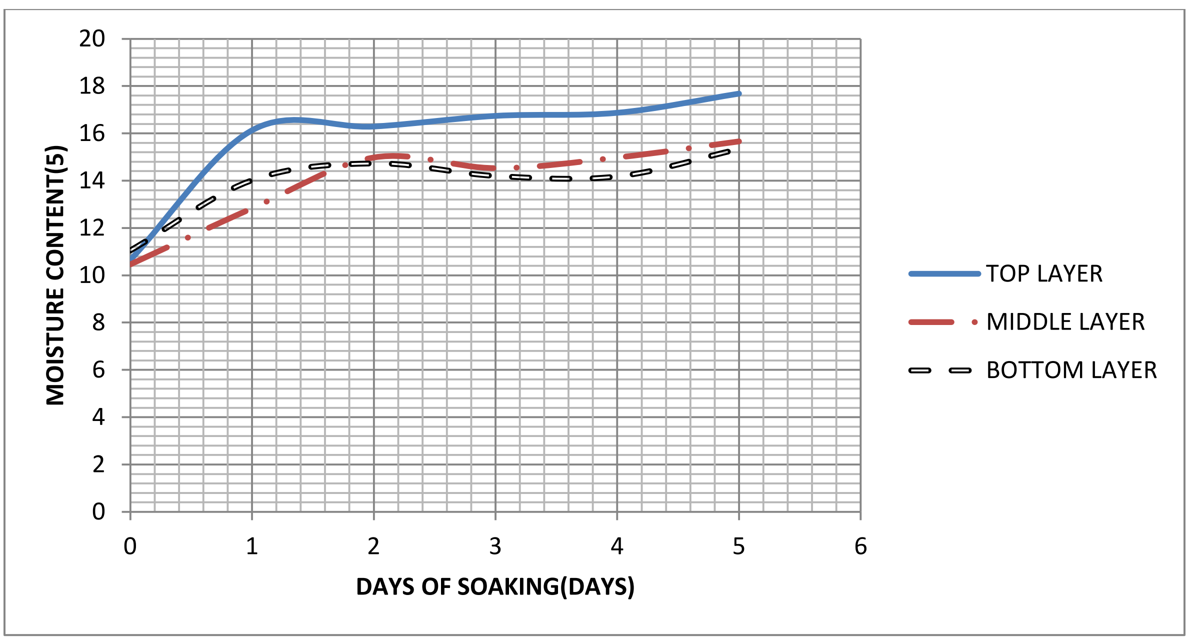
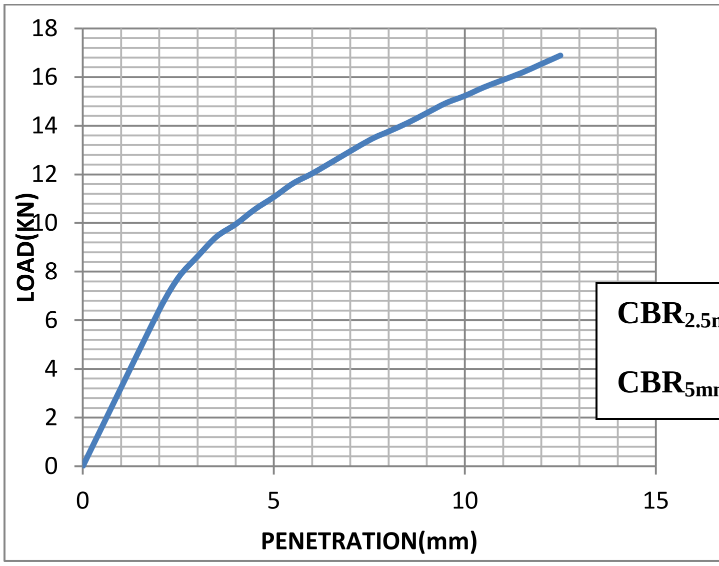


Fig-16

4.4.3 Test-3(at m/c-12% & dry density-2.008g/cc)

Unsoaked (Day 0)

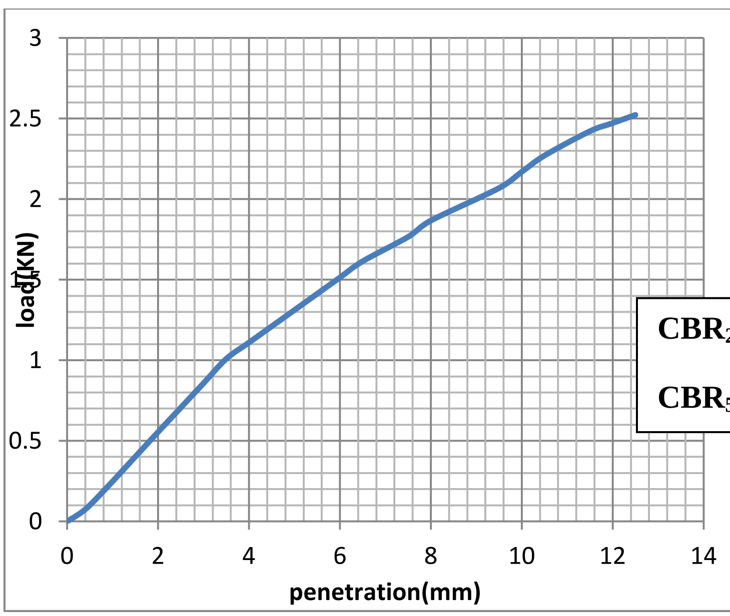


$CBR_{2.5mm}$=(882/1370)*100=64.37

CBR_{5mm}=(1184/2055)*100=57.16

Fig-17

Soaked (Day 1)-

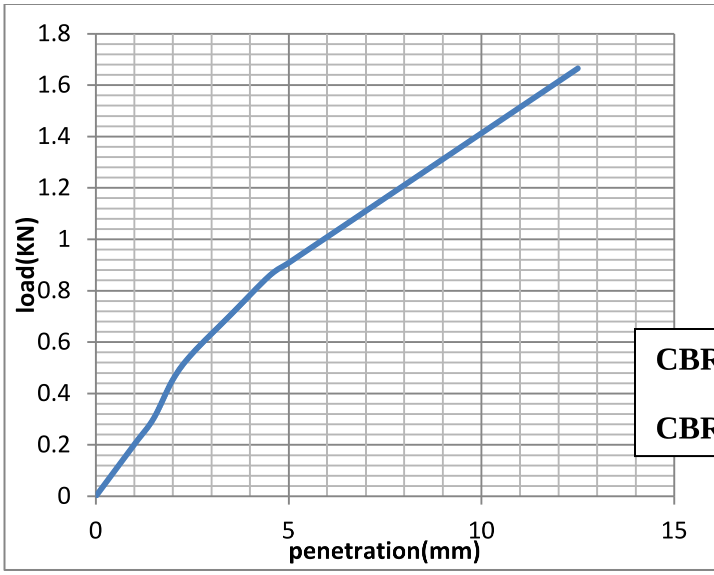


$CBR_{2.5mm}$=(70.63/1370)*100=5.15

CBR_{5mm}=(131.18/2055)*100=6.38

Fig-18

Soaked (DAY 2)-

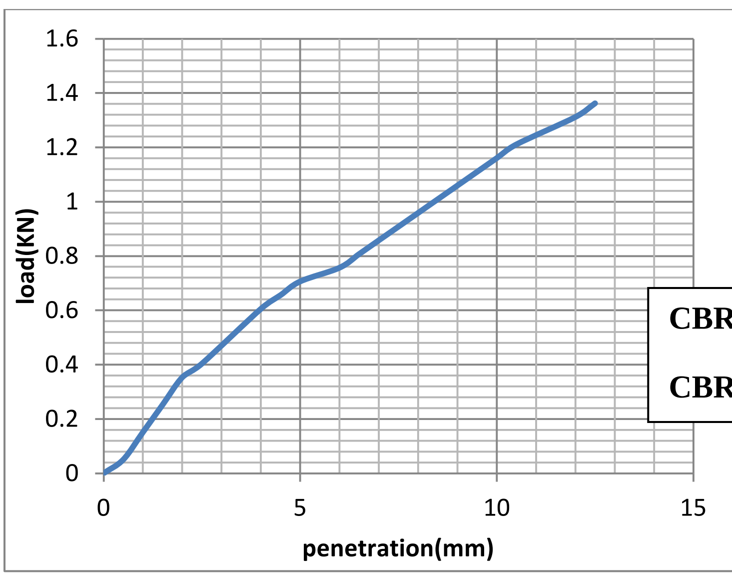


$CBR_{2.5mm}$=(62.3/1370)*100=4.55

CBR_{5mm}=(96/2055)*100=4.67

Fig-19

Soaked (DAY 3)

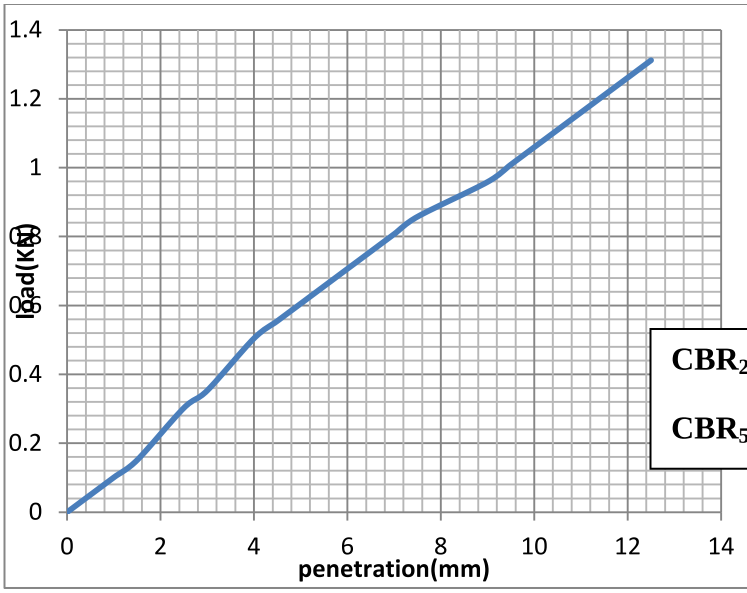


$CBR_{2.5mm}$=(44.2/1370)*100=3.23

CBR_{5mm}=(73.1/2055)*100=3.56

Fig-20

Soaked (DAY 4)-

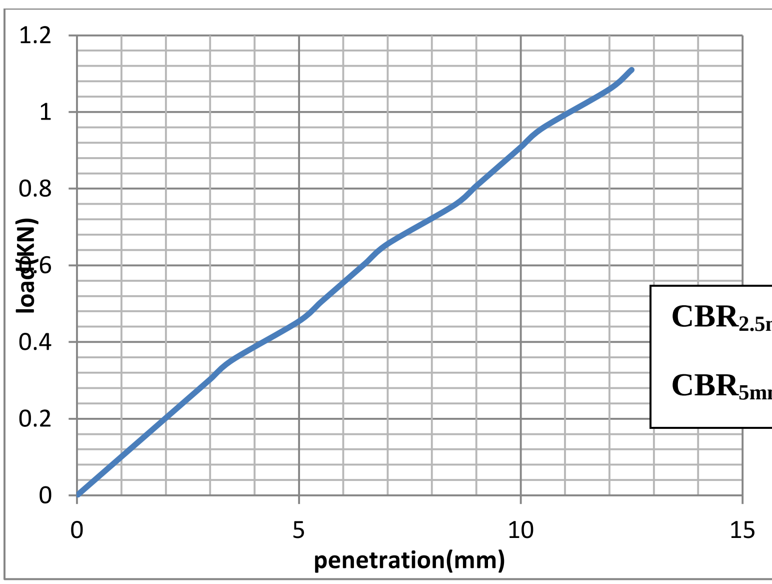


CBR$_{2.5mm}$=(30.275/1370)*100=2.21

CBR$_{5mm}$=(60.545/2055)*100=2.95

Fig-21

Soaked (DAY 5)-



CBR$_{2.5mm}$=(25.227/1370)*100=1.84

CBR$_{5mm}$=(45.4087/2055)*100=2.21

Fig-22

Table-7

Moisture content in %							
Unsoaked		Centre	East	West	North	South	Avg.
	Top	15.51	17.45	16.33	16.42	16.34	16.41
	Middle	16.72	16.41	16.31	16.79	16.12	16.47
	Bottom	16.38	16.91	17.12	17.24	17.33	16.99
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	16.87	16.38	17.98	17.70	18.37	17.46
	Middle	16.48	17.27	16.28	16.79	15.86	16.54
	Bottom	16.15	16.85	17.13	16.86	15.74	16.54
Soaked Day-2		Centre	East	West	North	South	Avg.
	Top	17.34	18.85	17.27	17.06	17.63	17.63
	Middle	16.16	15.59	16.69	16.51	16.55	16.30
	Bottom	16.88	16.87	16.88	17.24	16.34	16.84

Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	18.53	18.64	18.57	19.67	18.70	18.82
	Middle	17.38	17.17	17.38	17.83	17.32	17.416
	Bottom	16.90	17.58	16.55	17.32	17.05	17.08

		Centre	East	West	North	South	Avg.
Soaked Day-4	Top	19.27	20.08	20.87	20.42	20.15	20.158
	Middle	17.51	18.04	16.93	17.34	17.20	17.404
	Bottom	16.93	17.09	16.65	16.55	16.89	16.822
Soaked Day-5		Centre	East	West	North	South	Avg.
	Top	20.23	21.02	19.46	20.79	20.94	20.488
	Middle	20.00	19.17	20.04	20.28	19.55	19.81
	Bottom	19.93	20.47	19.66	21.13	19.36	20.11

Variation of moisture content with respect to days of soaking

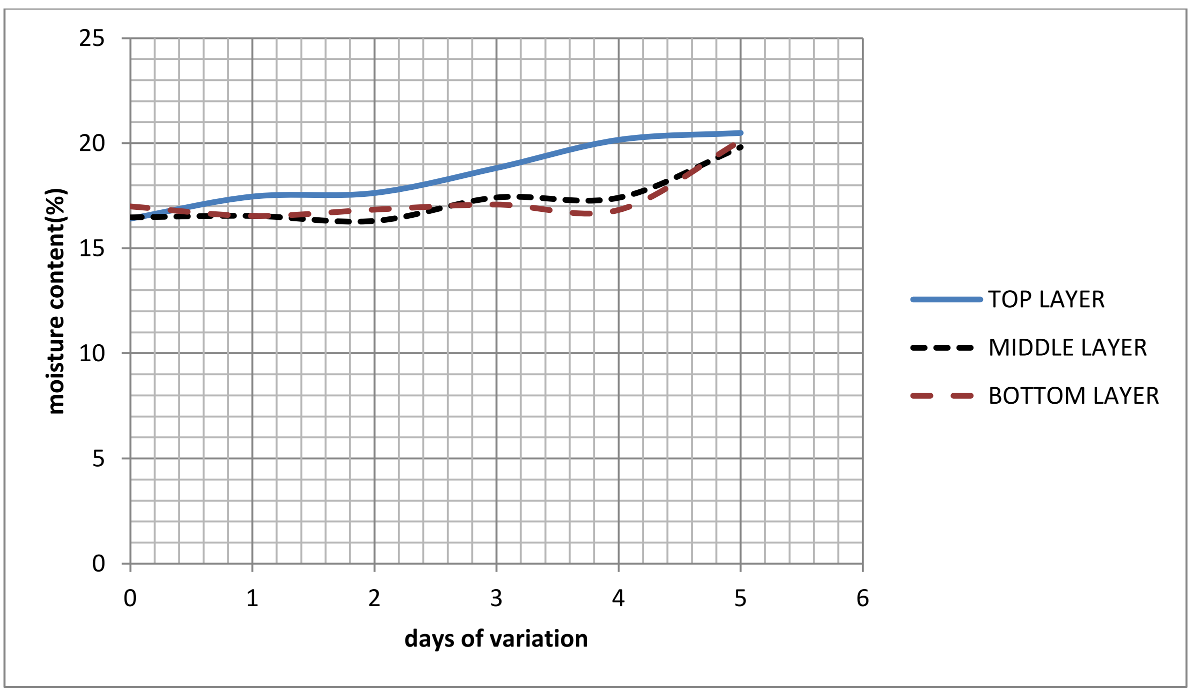
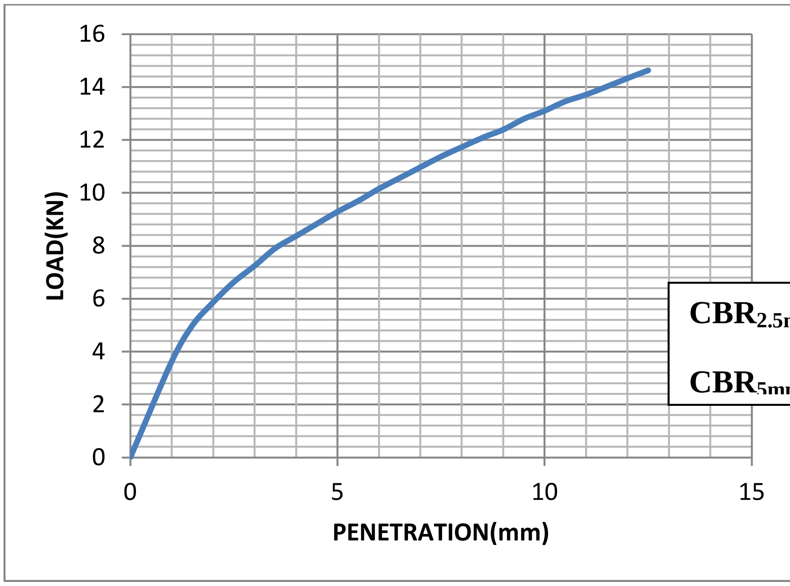


Fig-23

4.4.4 Test-4(at m/c-8% & dry density-1.9g/cc)

Unsoaked (DAY 0)

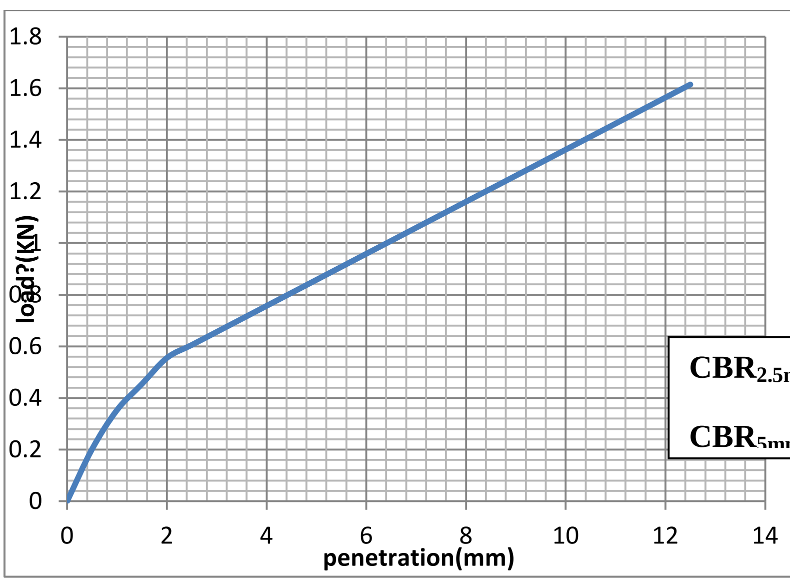


CBR$_{2.5mm}$=(710.2/1370)*100=51.84

CBR$_{5mm}$=(958/2055)*100=46.62

Fig-24

Soaked (DAY 1)

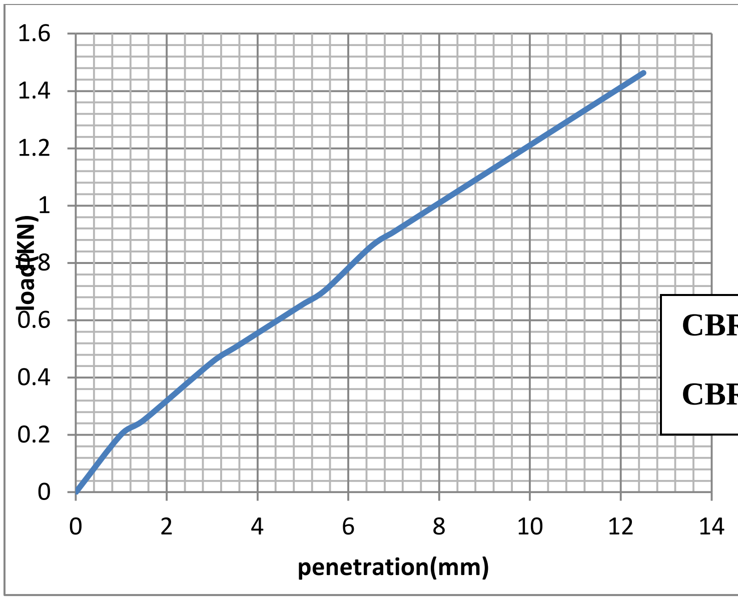


CBR$_{2.5mm}$=(60.545/1370)*100=4.42

CBR$_{5mm}$=(85.77/2055)*100=4.17

Fig-25

Soaked(DAY 2)

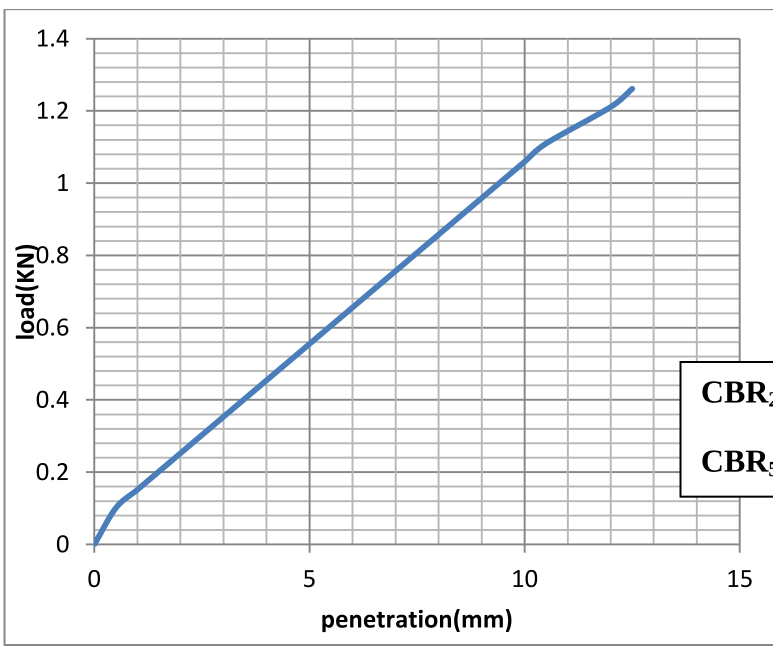


$CBR_{2.5mm}$=(35.32/1370)*100=2.58

CBR_{5mm}=(65.59/2055)*100=3.2

Fig-26

Soaked(DAY 3)

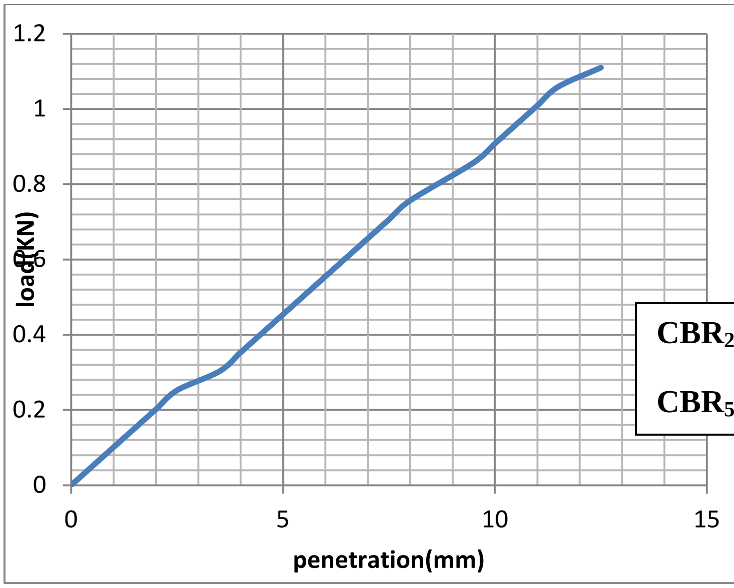


$CBR_{2.5mm}$=(30.27/1370)*100=2.21

CBR_{5mm}=(55.49/2055)*100=2.7

Fig-27

Soaked(DAY 4)

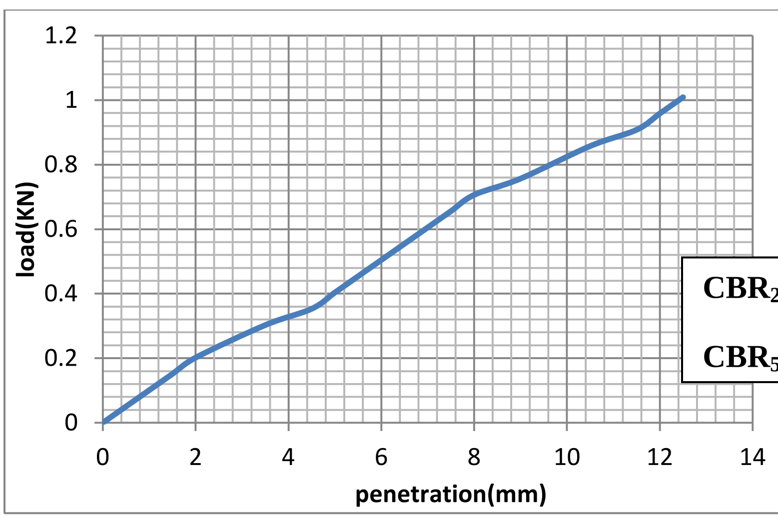


CBR$_{2.5mm}$=(25.227/1370)*100=1.84

CBR$_{5mm}$=(45.41/2055)*100=2.21

Fig-28

Soaked(DAY 5)



CBR$_{2.5mm}$=(25.23/1370)*100=1.84

CBR$_{5mm}$=(40.36/2055)*100=1.96

Fig-29

Table-8

Moisture content in %							
Unsoaked		Centre	East	West	North	South	Avg.
	Top	9.40	9.04	9.18	9.17	9.45	9.248
	Middle	9.41	9.13	9.34	9.41	9.18	9.294
	Bottom	9.70	9.62	9.72	9.19	9.49	9.544
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	16.32	16.59	16.39	16.16	15.83	16.258
	Middle	15.14	15.12	14.57	15.42	15.00	15.05
	Bottom	14.33	14.43	14.16	14.45	14.11	14.296
Soaked Day-2		Centre	East	West	North	South	Avg.
	Top	16.75	16.94	16.73	17.14	17.07	16.926
	Middle	16.12	16.82	16.32	15.96	16.62	16.368
	Bottom	15.54	15.56	15.60	16.41	15.81	15.784

Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	17.71	17.68	18.35	18.54	17.84	18.024
	Middle	17.25	17.19	17.02	16.97	16.88	17.062
	Bottom	16.14	16.68	16.20	16.09	16.86	16.394

		Centre	East	West	North	South	Avg.
Soaked Day-4	Top	19.01	19.60	18.59	19.30	19.50	19.20
	Middle	18.29	18.68	17.96	18.15	18.24	18.264
	Bottom	17.54	18.19	18.05	18.21	18.06	18.01
		Centre	East	West	North	South	Avg.
Soaked Day-5	Top	19.90	21.42	20.11	20.59	22.17	20.838
	Middle	19.57	20.53	18.61	19.47	19.81	19.598
	Bottom	20.03	18.53	20.43	19.70	19.13	19.564

Variation of moisture content with respect to days of soaking

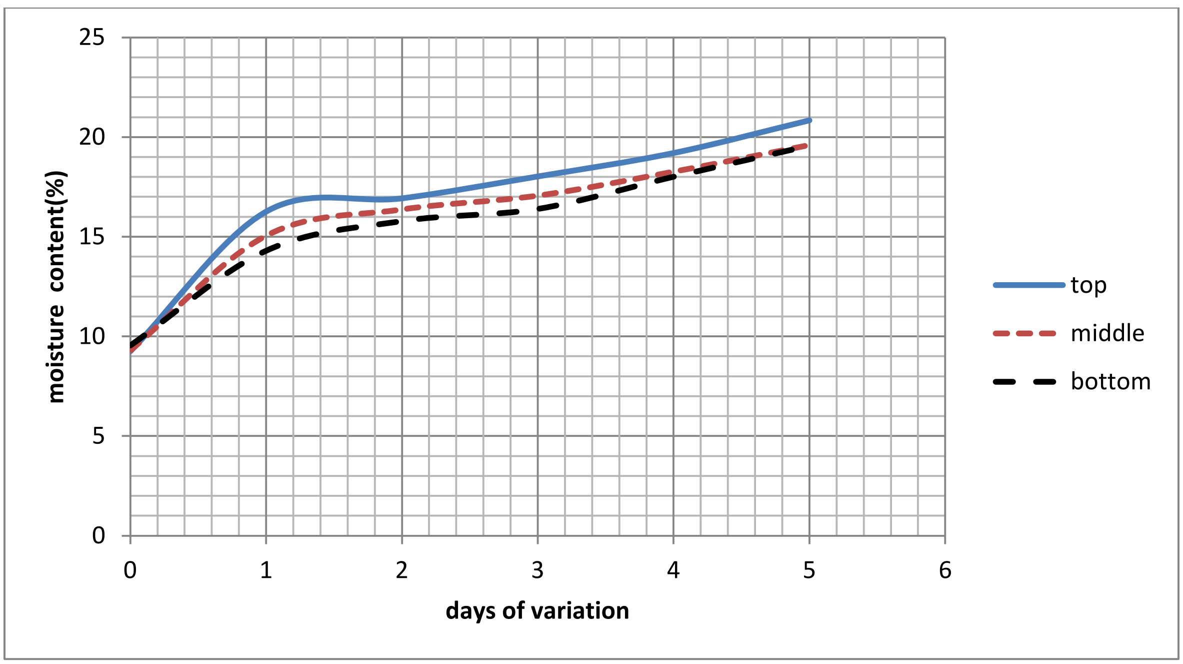


Fig-30

CBR Values and their variation with days of soaking

Test-1

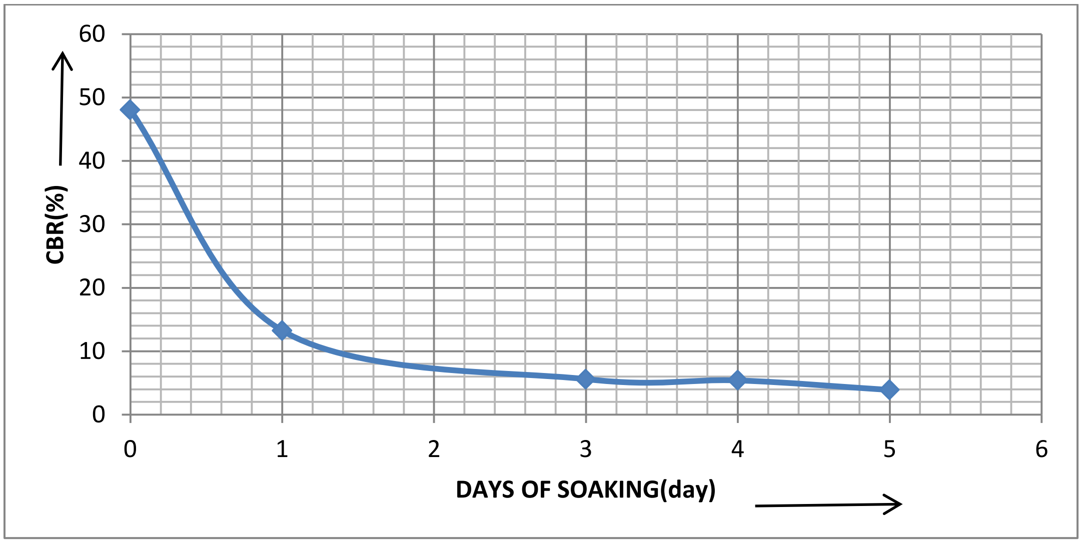


Fig-31

Test-2

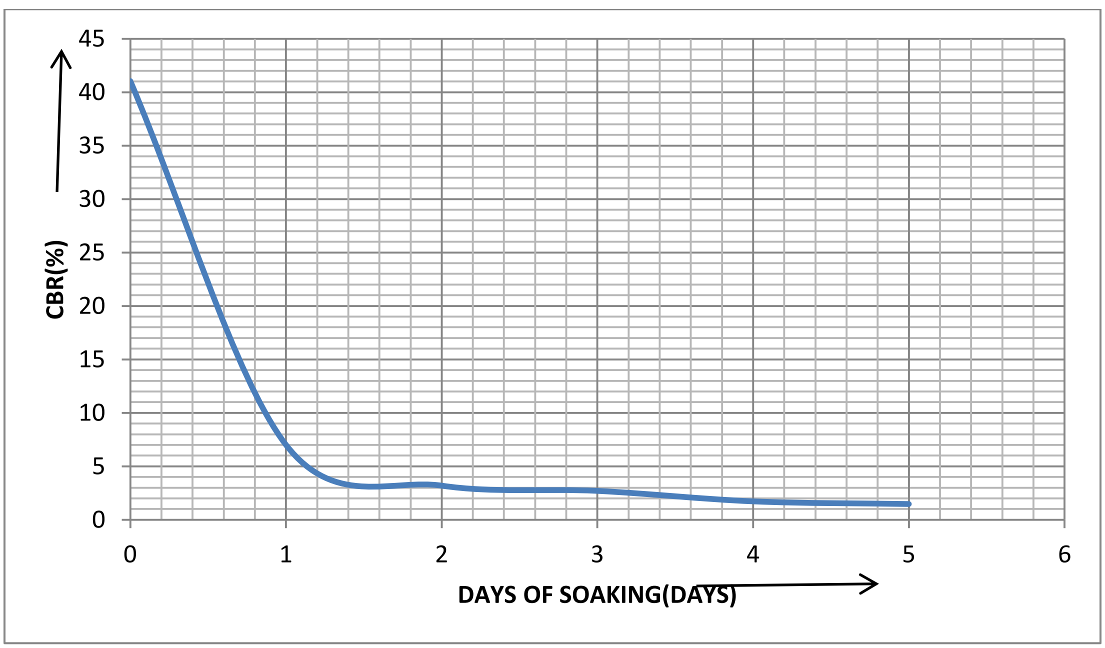


Fig-32

Test-3

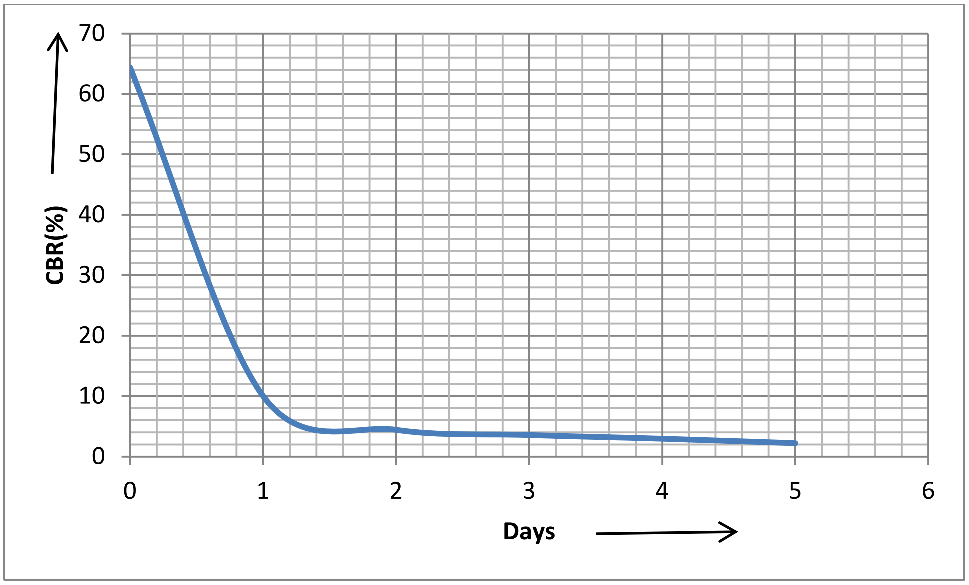


Fig-33

Test-4

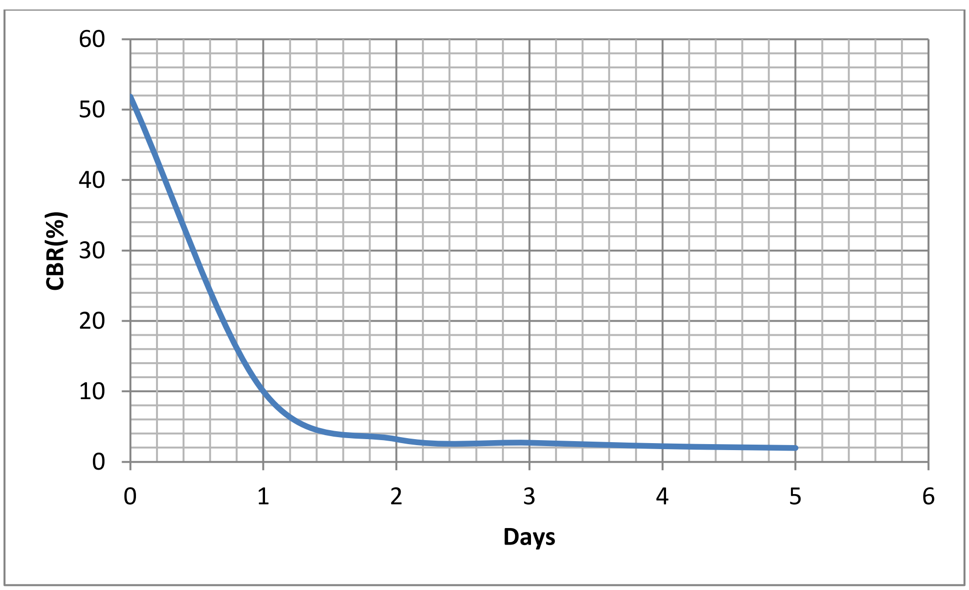


Fig-34

4.2 Soil Sample-2

4.2.1 index properties

Table -9- index properties of soil sample 2

Index property	Experimental value(%)
Liquid limit	52.3
Plastic limit	25.5
Plasticity index	26.8

The type of soil as per classification is CH type

4.2.2 Grain size distribution-

Table-10 The grain size distribution of soil sample 2

B.I.S. Sieve	weight retained in (gm)	percentage weight retained	Cumulative percentage retained	Percentage Weight Passing (%)
4.75 mm	12.7	1.27	1.27	98.73
2.36 mm	5.1	0.51	1.78	98.22
1.18 mm	11.8	1.18	2.96	97.04
600 µm	22.9	2.29	5.25	94.75
300 µm	10	1.0	6.25	93.75
150 µm	20.2	2.02	8.27	91.73
75 µm	29.4	2.94	11.21	88.79

4.2.3 Modified proctor test

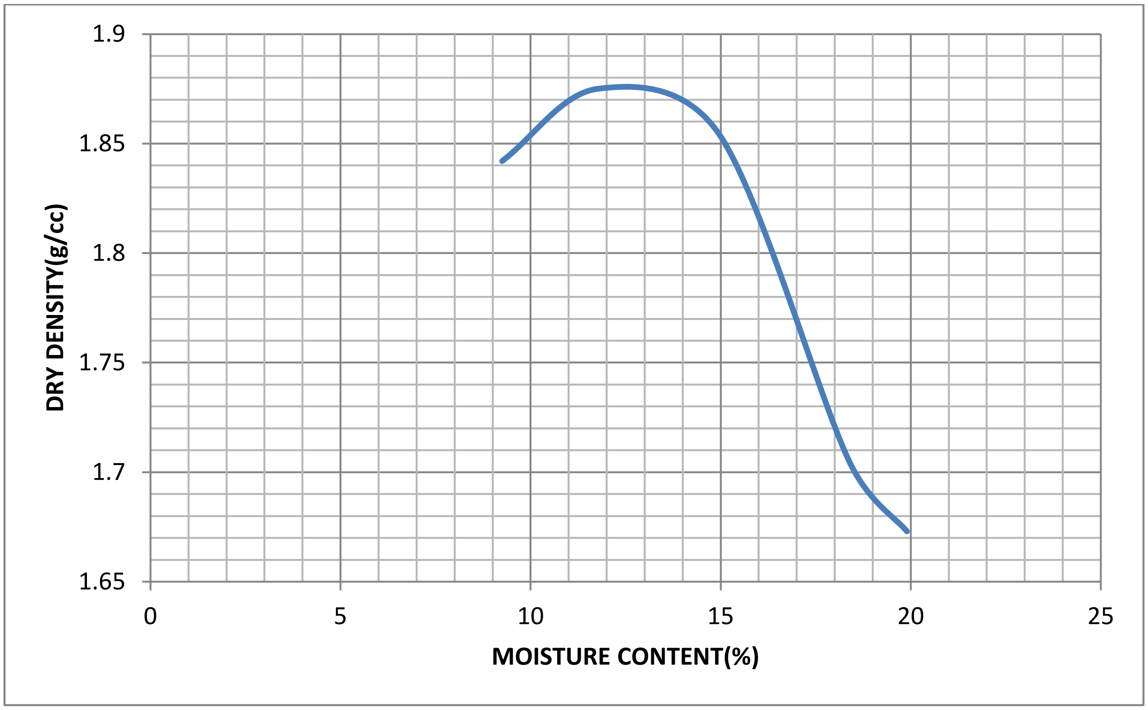


Fig-35

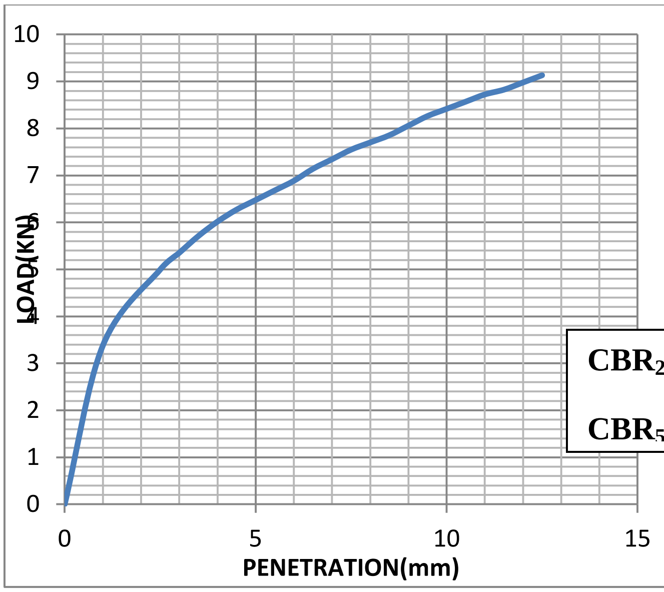
From the graph it was found that

OMC=12.5% & MDD=1.877 g/cc

4.2.4 CBR Tests

Test 1- at OMC and MDD

Unsoaked?(Day 0)

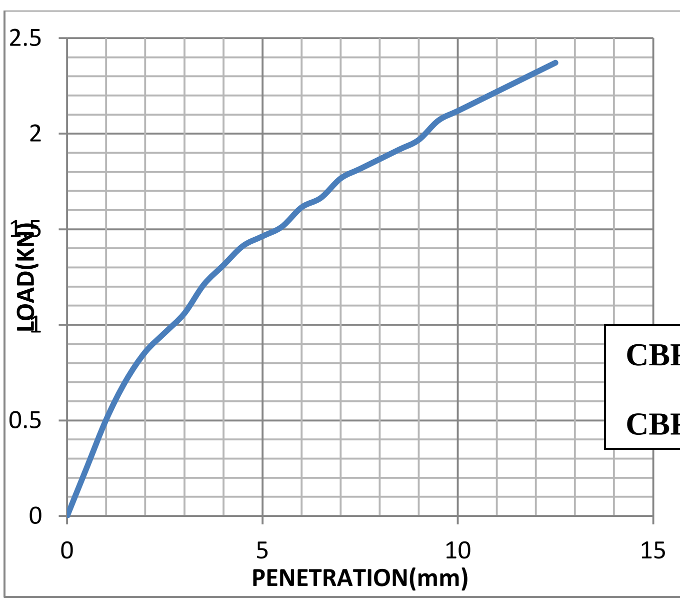


CBR$_{2.5mm}$=(499.49/1370)*100=36.46

CBR$_{5mm}$=(647.6/2055)*100=31.5

Fig-36

Soaked (Day 1)

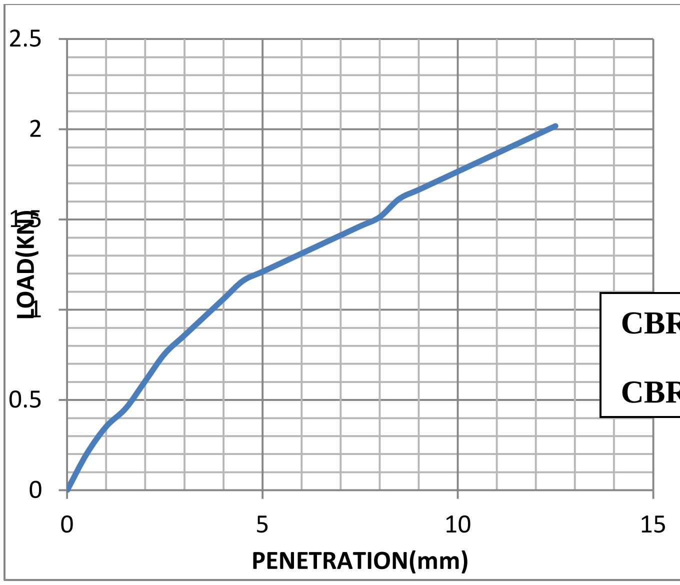


CBR$_{2.5mm}$=(95.86/1370)*100=6.99

CBR$_{5mm}$=(146.32/2055)*100=7.12

Fig-37

Soaked (Day 2)-

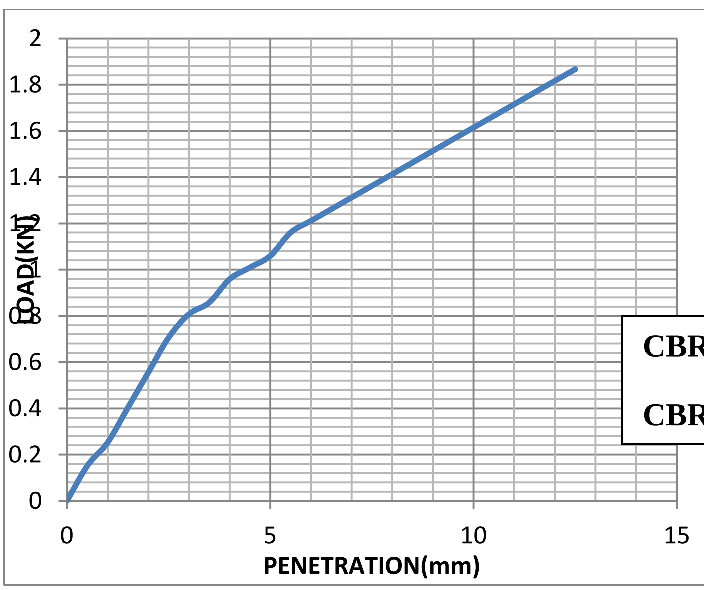


CBR$_{2.5mm}$=(75.68/1370)*100=5.52

CBR$_{5mm}$=(121.08/2055)*100=5.89

Fig-38

Soaked (Day 3)

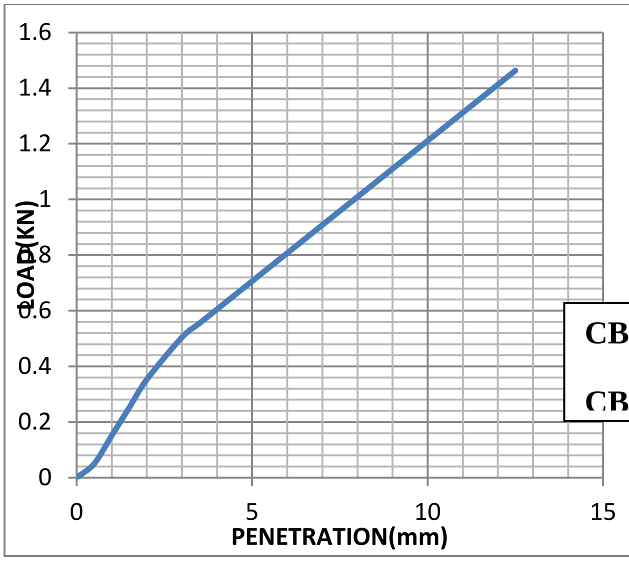


CBR$_{2.5mm}$=(70.64/1370)*100=5.16

CBR$_{5mm}$=(105.95/2055)*100=5.15

Fig-39

Soaked (Day 4)

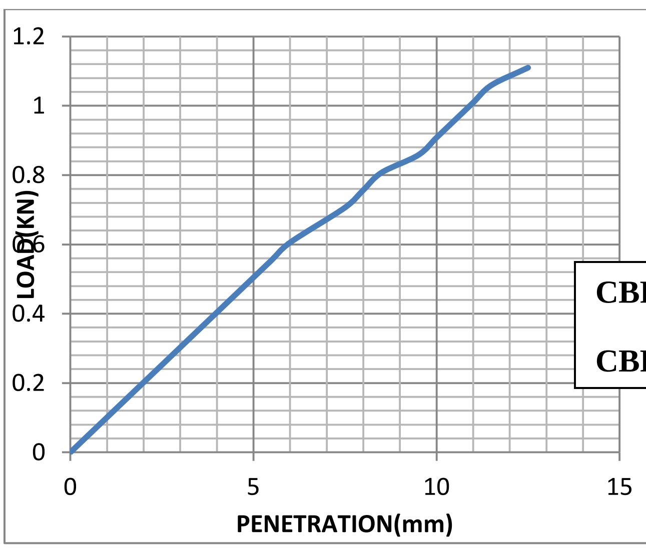


$CBR_{2.5mm}$=(46.2/1370)*100=3.37

CBR_{5mm}=(72.35/2055)*100=3.52

Fig-40

Soaked (Day 5)



$CBR_{2.5mm}$=(25.23/1370)*100=1.84

CBR_{5mm}=(50.45/2055)*100=2.45

Fig-41

Table-11

Moisture content in %							
Unsoaked		Centre	East	West	North	South	Avg.
	Top	11.94	11.34	11.04	11.81	11.99	11.62
	Middle	11.27	10.10	11.98	10.52	10.74	10.92
	Bottom	10.60	11.90	12.90	13.12	12.02	12.10
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	14.05	15.36	14.91	15.54	15.37	15.04
	Middle	13.73	14.10	13.66	14.55	13.40	13.88
	Bottom	14.81	13.41	14.65	14.27	13.80	14.19
Soaked Day-2		Centre	East	West	North	South	Avg.
	Top	16.17	16.77	16.13	16.35	16.03	16.29
	Middle	15.99	14.85	14.50	15.25	14.58	15.03
	Bottom	14.41	15.22	15.50	14.71	14.25	14.82

Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	17.33	18.27	16.35	18.08	17.87	17.58
	Middle	16.41	16.79	16.19	16.72	16.30	16.48
	Bottom	16.38	17.23	17.33	16.90	17.19	17.00

		Centre	East	West	North	South	Avg.
Soaked Day-4	Top	20.03	19.81	19.95	18.34	19.47	19.52
	Middle	20.80	18.54	17.42	16.70	18.68	18.43
	Bottom	16.39	17.44	17.83	16.70	18.18	17.31
		Centre	East	West	North	South	Avg.
Soaked Day-5	Top	20.79	21.54	20.95	21.02	19.46	20.75
	Middle	19.17	20.28	20.20	20.00	20.03	19.94
	Bottom	19.93	21.13	19.36	19.84	19.66	19.89

Variation of moisture content with respect to days of soaking

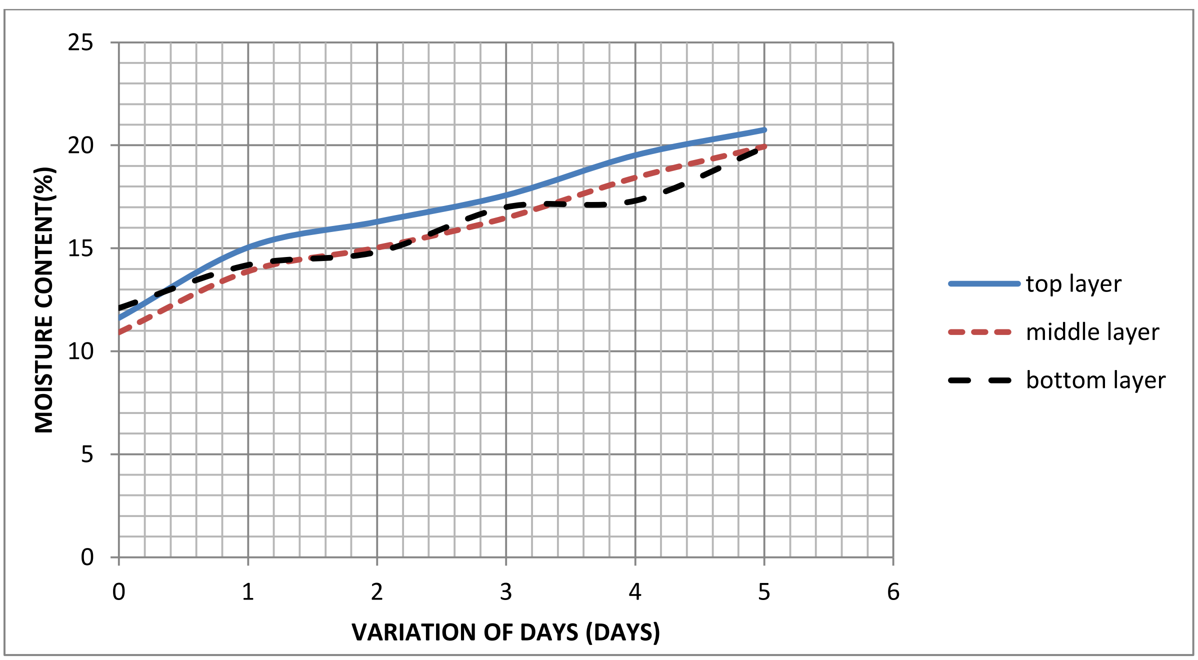
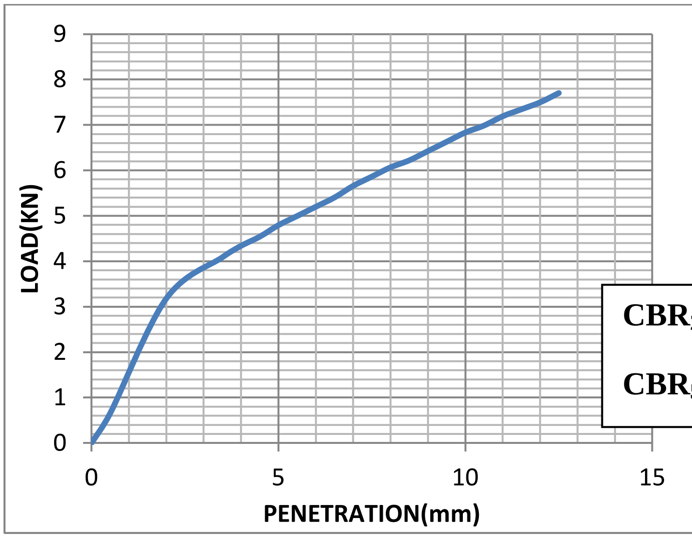


Fig-42

Test-2-at m/c=10% % & dry density=1.853 g/cc

Unsoaked (Day 0)

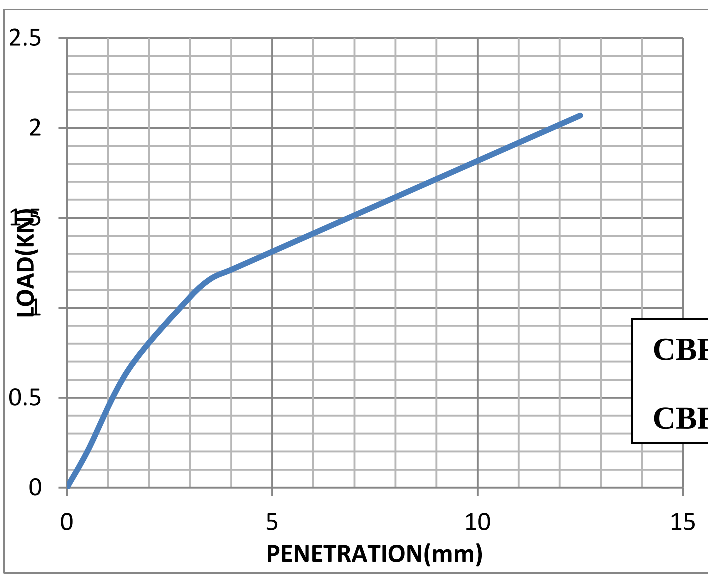


$CBR_{2.5mm}$=(362.5/1370)*100=26.46

CBR_{5mm}=(491.2/2055)*100=23.9

Fig-43

Soaked (Day 1)

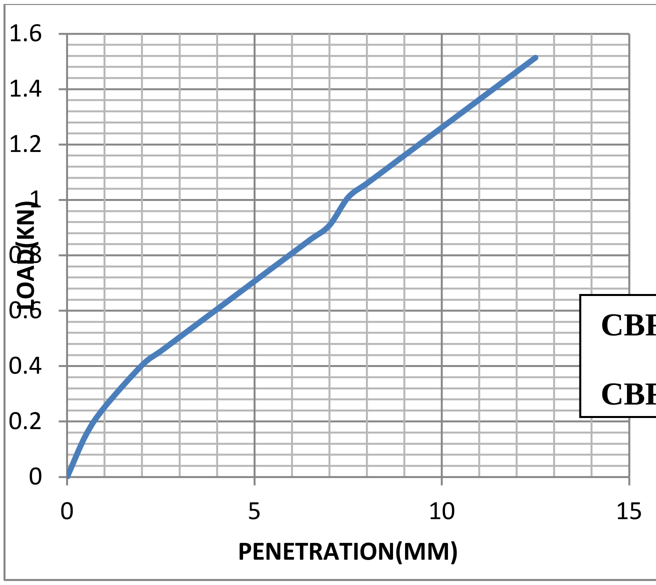


$CBR_{2.5mm}$=(100.91/1370)*100=7.36

CBR_{5mm}=(131.18/2055)*100=6.38

Fig-44

Soaked (Day 2)

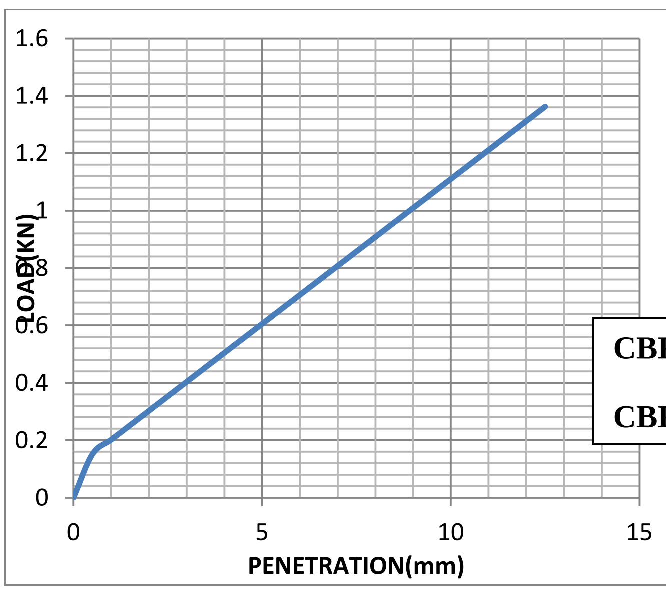


$CBR_{2.5mm}$=(45.4/1370)*100=3.31

CBR_{5mm}=(70.63/2055)*100=3.44

Fig-45

Soaked (Day 3)

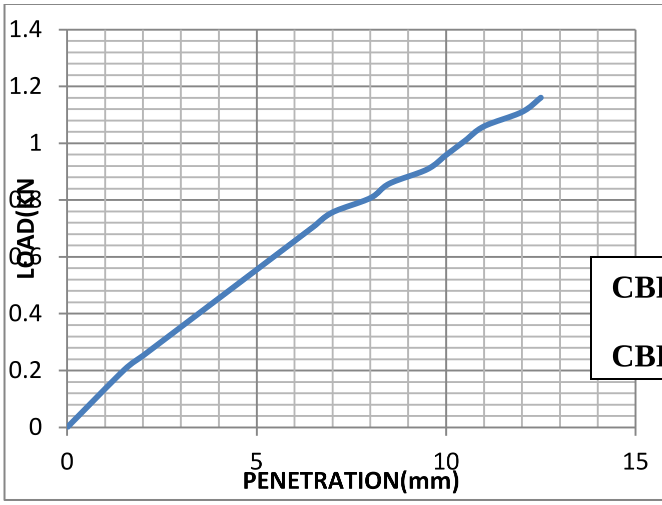


$CBR_{2.5mm}$=(35.32/1370)*100=2.58

CBR_{5mm}=(60.55/2055)*100=2.95

Fig-46

Soaked (Day 4)

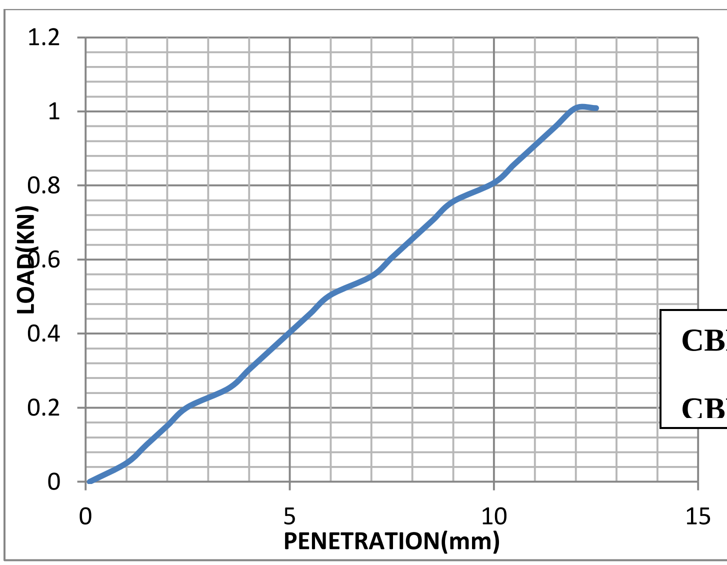


CBR$_{2.5mm}$=(32.3/1370)*100=2.36

CBR$_{5mm}$=(54.6/2055)*100=2.66

Fig-47

Soaked (Day 5)



CBR$_{2.5mm}$=(20.3/1370)*100=1.48

CBR$_{5mm}$=(40.5/2055)*100=1.97

Fig-48

Table-12

Moisture content in %							
Unsoaked		Centre	East	West	North	South	Avg.
	Top	13.21	12.88	12.19	12.23	13.37	12.77
	Middle	12.78	11.82	12.54	10.39	12.05	11.91
	Bottom	13.49	12.81	10.14	13.12	12.02	12.31
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	14.14	15.03	15.23	13.63	15.03	14.61
	Middle	15.12	15.88	14.53	13.02	13.57	14.42
	Bottom	13..75	13.90	14.75	13.01	13.18	13.72
Soaked Day-2		Centre	East	West	North	South	Avg.
	Top	16.36	16.03	15.82	17.07	16.50	16.35
	Middle	16.98	16.27	17.33	16.17	17.16	17.38
	Bottom	16.18	17.25	15.73	16.79	15.28	16.25

Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	18.04	17.22	17.80	17.35	17.76	17.63
	Middle	16.44	17.64	16.47	17.56	16.36	16.89
	Bottom	16.25	16.31	16.55	15.69	15.58	16.07

		Centre	East	West	North	South	Avg.
Soaked Day-4	Top	18.86	19.19	20.90	20.05	21.74	20.15
	Middle	20.01	19.06	20.54	20.16	19.81	19.91
	Bottom	20.42	20.57	19.98	20.72	19.51	20.24
		Centre	East	West	North	South	Avg.
Soaked Day-5	Top	20.83	21.70	22.19	22.23	20.16	21.42
	Middle	20.25	21.51	21.13	21.18	22.45	21.30
	Bottom	20.72	22.90	20.50	19.75	21.45	21.06

Variation of moisture content with respect to days of soaking

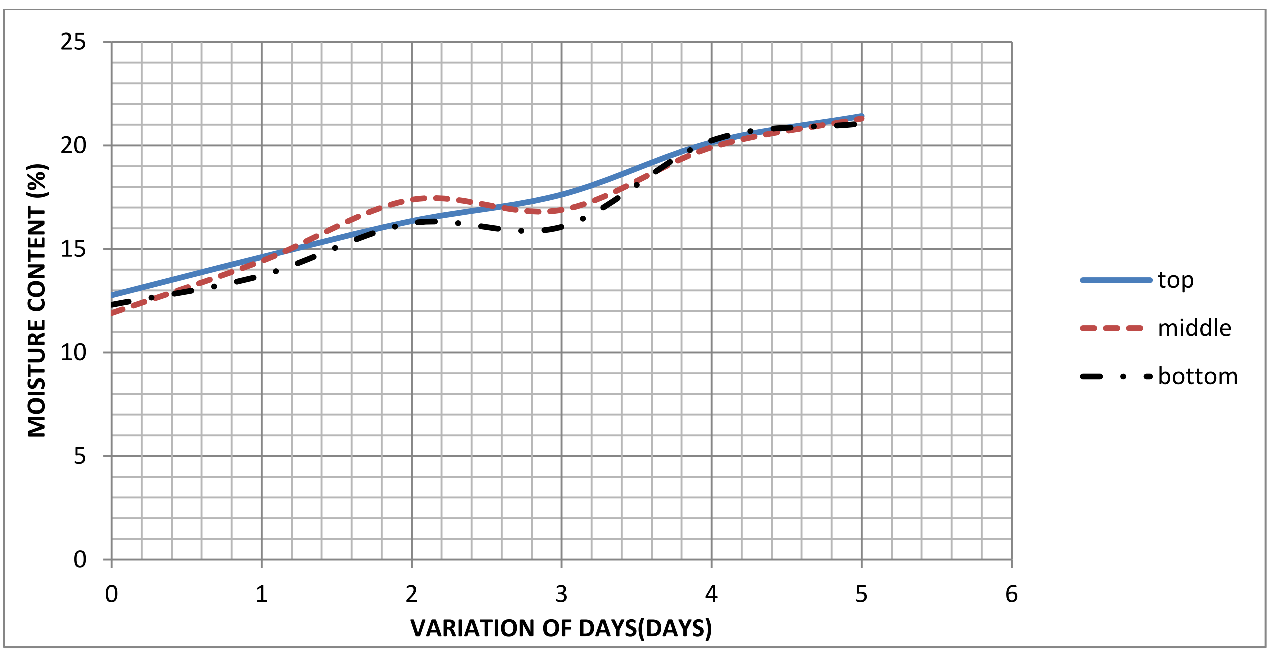
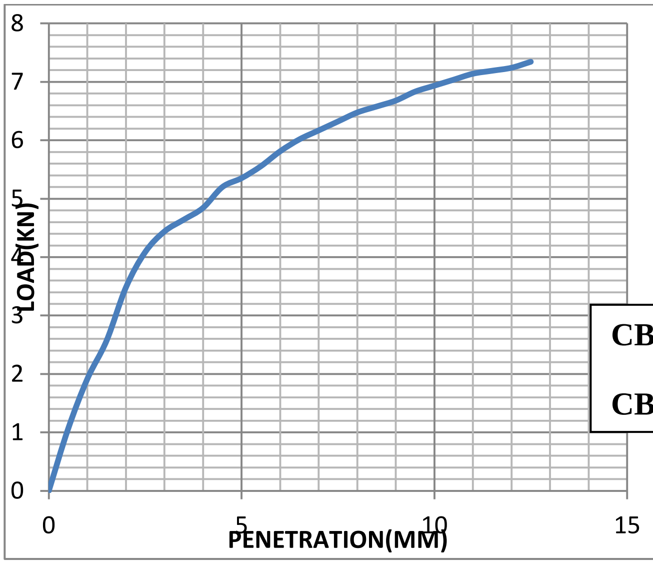


Fig-49

Test 3- at m/c=15.5% & dry density=1.832 g/cc

Unsoaked (Day 0)

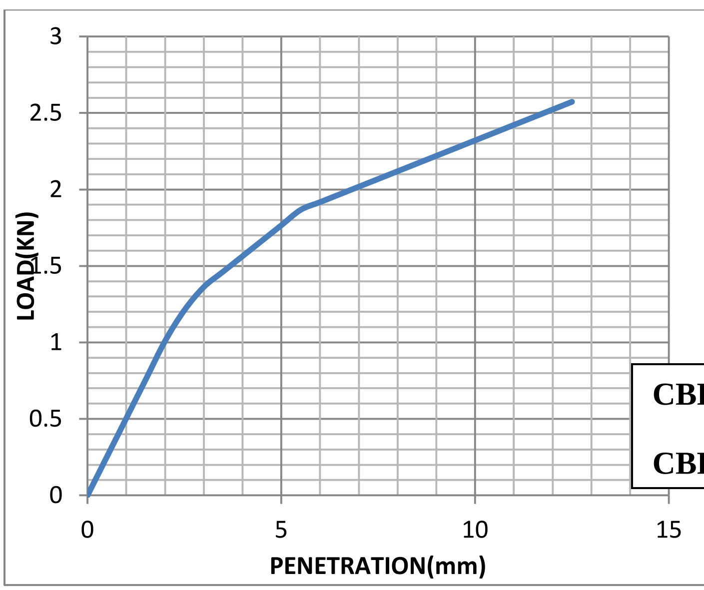


$CBR_{2.5mm}$=(408.67/1370)*100=29.83

CBR_{5mm}=(535.242055)*100=26.04

Fig-50

Soaked (Day 1)

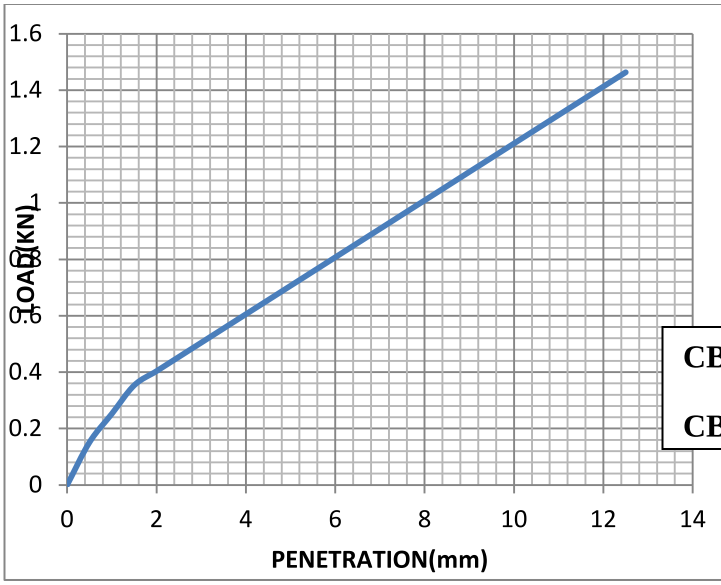


$CBR_{2.5mm}$=(121.1/1370)*100=8.84

CBR_{5mm}=(176.58/2055)*100=8.59

Fig-51

Soaked (Day 2)

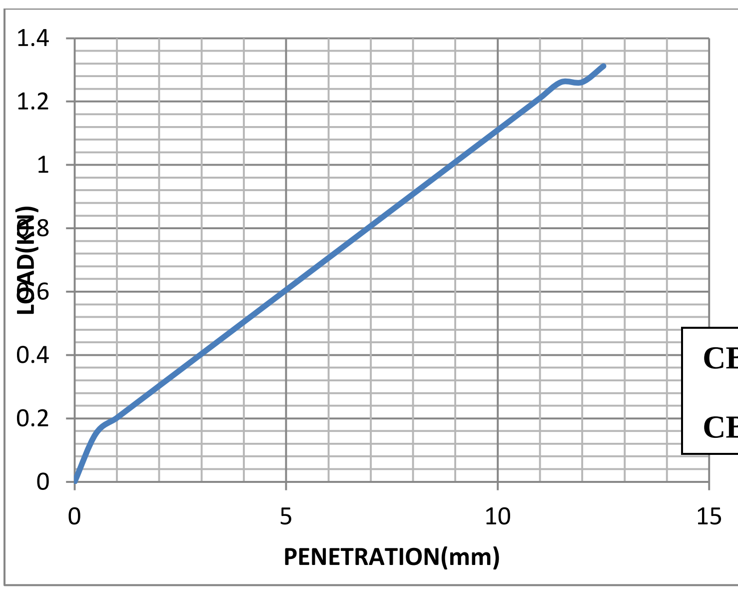


$CBR_{2.5mm}$=(45.4/1370)*100=3.31

CBR_{5mm}=(70.64/2055)*100=3.44

Fig-52

Soaked (Day 3)

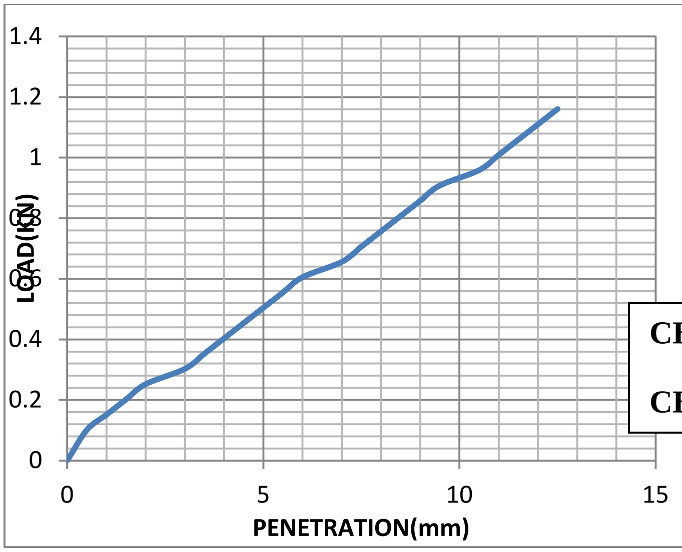


$CBR_{2.5mm}$=(35.32/1370)*100=2.58

CBR_{5mm}=(60.55/2055)*100=2.95

Fig-53

Soaked (Day 4)

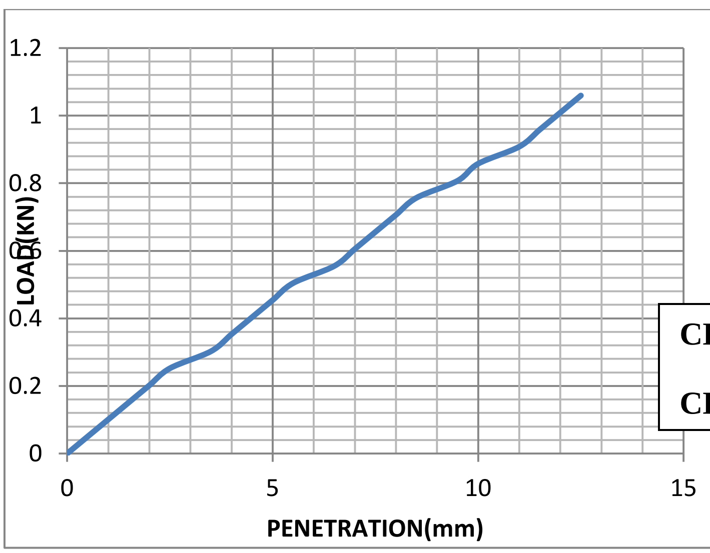


$CBR_{2.5mm}$=(30.27/1370)*100=2.21

CBR_{5mm}=(50.45/2055)*100=2.45

Fig-54

Soaked (Day 5)



$CBR_{2.5mm}$=(25.23/1370)*100=1.84

CBR_{5mm}=(45.4/2055)*100=2.21

Fig-55

Table-13

Moisture content in %							
Unsoaked		Centre	East	West	North	South	Avg.
	Top	11.21	10.60	8.26	9.32	10.27	9.93
	Middle	9.62	8.61	9.65	9.96	11.99	9.96
	Bottom	8.10	10.53	9.46	8.88	8.52	9.10
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	13.40	13.62	13.19	14.52	13.17	13.52
	Middle	12.64	11.91	13.28	13.53	12.85	12.84
	Bottom	13.65	12.33	13.83	12.30	14.13	13.25
Soaked Day-2		Centre	East	West	North	South	Avg.
	Top	16.68	18.82	15.08	16.15	15.44	16.34
	Middle	18.31	16.44	16.64	18.81	16.38	16.71
	Bottom	15.48	17.43	18.46	14.23	14.59	16.03
Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	17.65	16.98	17.35	18.66	18.02	17.73
	Middle	16.18	18.52	17.34	20.86	18.14	18.21
	Bottom	16.20	17.89	17.07	18.16	17.60	17.38

		Centre	East	West	North	South	Avg.
Soaked Day-4	Top	18.55	19.32	20.51	18.16	21.38	19.58
	Middle	19.18	18.93	19.81	20.45	18.75	19.42
	Bottom	19.54	21.86	20.19	20.10	19.59	20.25
Soaked Day-5		Centre	East	West	North	South	Avg.
	Top	21.60	22.26	20.98	22.20	21.88	21.78
	Middle	21.84	22.60	20.73	22.39	23.13	22.13
	Bottom	23.05	21.17	20.97	23.21	21.87	22.05

Variation of moisture content with respect to days of soaking

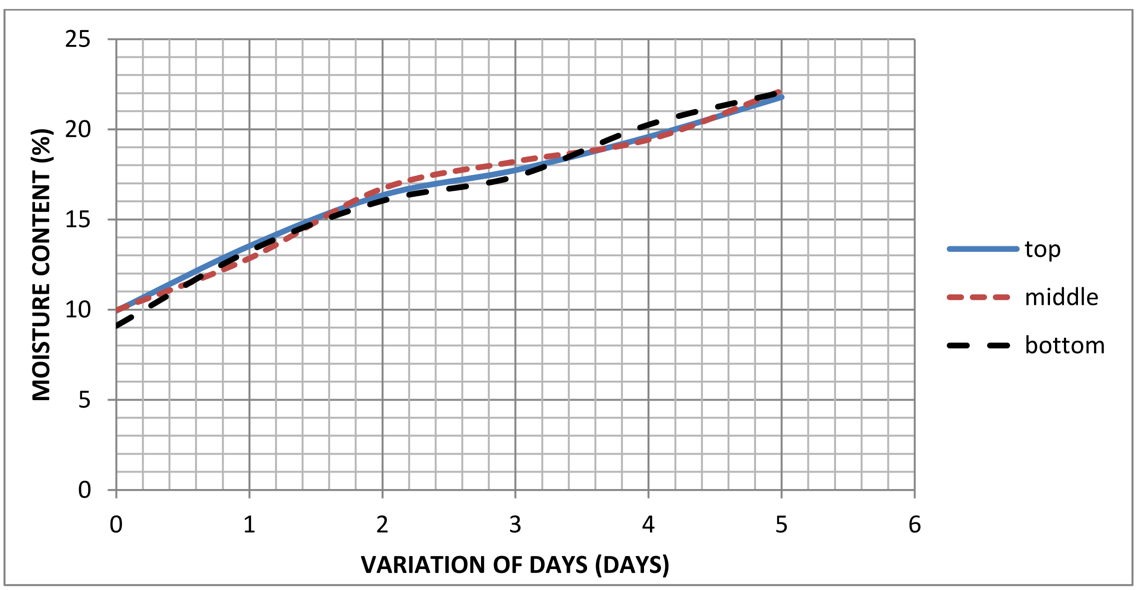


Fig-56

Variation of CBR with respect to days of soaking

Test 1

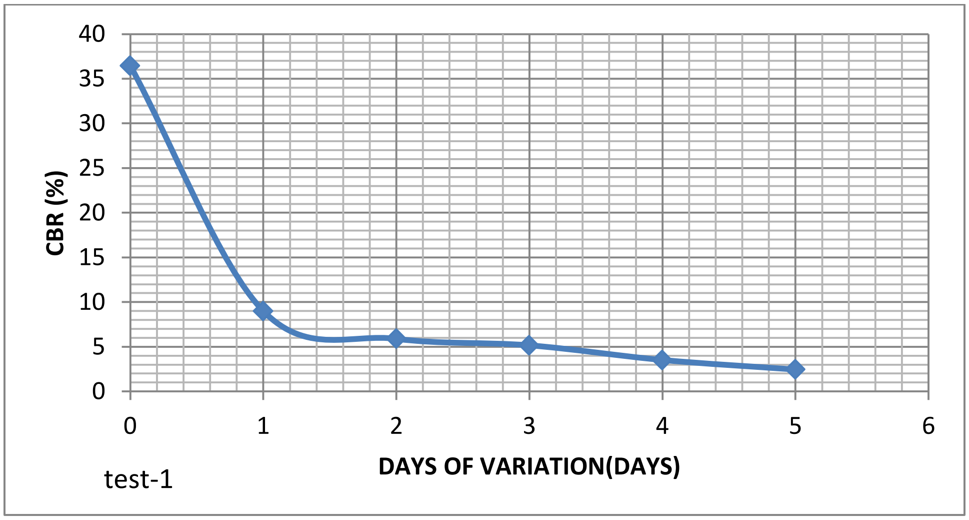


Fig-57

Test 2

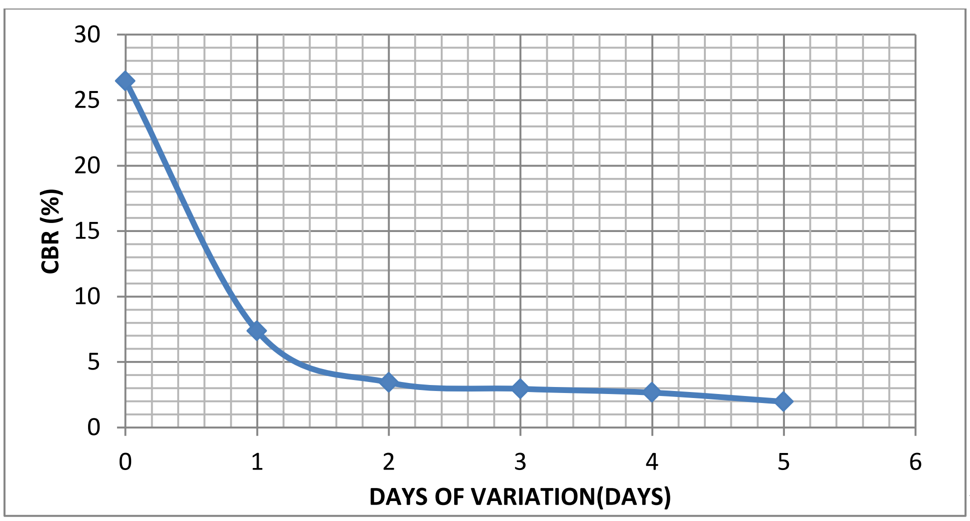


Fig-58

Test 3

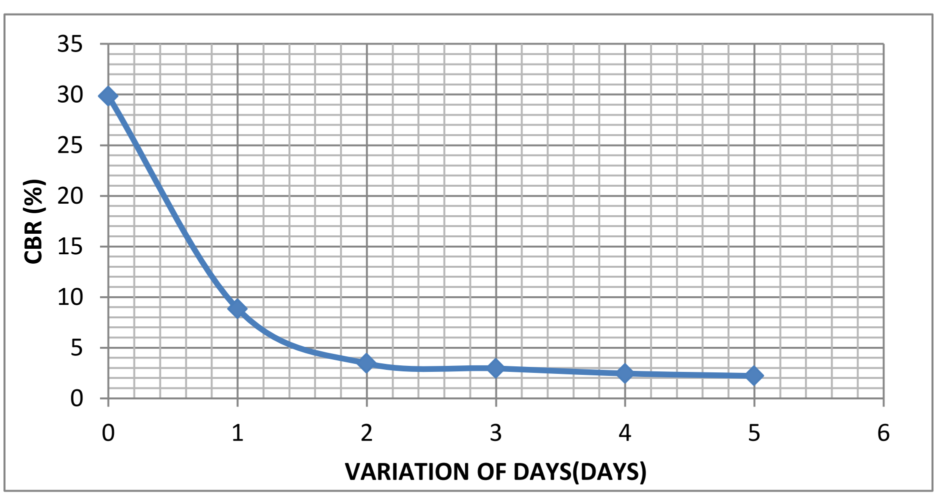


Fig-59

5 .*CONCLUSIONS*

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CONCLUSIONS

From the results and discussions of several tests conducted on only two types of soil samples as described before, it is concluded that the value of CBR for the given soil sample decreases rapidly from unsoaked condition to 1 day of soaking. Further increase in the number of days of soaking decreases the CBR value gradually and at a slower rate. It is also observed that the loss of CBR value between conditions of 1-day and 4-days soaking is also substantial and significant loss of strength is observed. However, it is also observed that the moisture contents in general remain almost similar after 1 day of soaking. Recommending soils to go for 4-day soaked CBR test may not hold good for all kind of soils. It is observed that for non-expansive soils, the variation of CBR after 1 day of soaking is not significant and hence it is not recommended to go for such soil being soaked for shorter period thus resulting less crust thickness and consequentially saves considerably the pavement costs. Whereas for expansive soils, the variation between 2-day and 4-day soaking values are quite different. However, more studies involving a variety of soils are required to substantiate the above finding.

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